A CENOMANIAN MICROFAUNA FROM UPPER FORT ST. JOHN STRATA

R.E. WETTER

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THE UNIVERSITY OF ALBERTA

A CENOMANIAN MICROFAUNA FROM UPPER FORT ST. JOHN STRATA

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE

DEPARTMENT OF GEOLOGY

by

RAYMOND EMIL WETTER

EDMONTON, ALBERTA

APRIL 7, 1951.

FRONTISPIECE

Peace River Valley, British Columbia, showing the original site of Fort St. John trading post on the flat at right centre. Outcrop of shales at lower right are the Upper Fort St. John group which Selwyn first examined in 1875.

PREFACE AND ACKNOWLEDGEMENTS

Correlation and dating of the complex sequence of Cretaceous strata in the Western Canadian Plains has been restricted by incomplete palaeontological and lithological evidence. The major problem involving the Cretaceous sequence has been the determination of time-stratigraphic equivalents from marine to non-marine facies.

Until recently, the Fort St. John group was considered to be entirely Lower Cretaceous in age. Recently, the uppermost Fort St. John beds have been assigned a Cenomanian age. Much work remains to be done before the precise stratigraphic relationships of the Fort St. John group are fully known.

Some recent work has been done on the Cretaceous microfauna of the Western Canadian Plains. Published reports by R. T. D. Wickenden, J. A. Cushman, and A. W. Nauss, and unpublished papers by C. R. Stelck, J. H. Wall, D. B. Bullock, A. R. Nielsen, W. G. Bahan, A. W. Norris, and F. H. Trollope provide groundwork for the identification of Cretaceous microfaunas of the foothills and plains.

In order to supplement this work, the author has undertaken a study of a microfauna from the upper part of the Fort St. John group from the type area near Fort St. John, British Columbia.

The writer wishes to express his sincere appreciation to all members of the Department of Geology, University of Alberta, for their assistance and encouragement during the writer's graduate and undergraduate years.

The writer wishes especially to express his appreciation for the assistance and advice rendered him by Dr. C. R. Stelck, under whose direction this thesis was written.

Cordial thanks are also extended to Pacific Petroleums Limited, for financial assistance; to W. G. Bahan of Pacific Petroleums Limited, for the use of photographs and data; and to J. H. Wall, R. A. Burwash, and A. D. Berry for advice and assistance in the photographic procedure.

The writer has had continual access to unpublished works and microfaunal suites of C. R. Stelck, D. B. Bullock and A. R. Nielsen.

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ABSTRACT

Twenty-two species of Foraminifera from the upper part of the Fort St. John group in the type area near Fort St. John, British Columbia, are described and illustrated. All of the species described are arenaceous forms, and include: 3 species each of Ammobaculites, and Nodosinella; 4 of Miliammina; 2 each of Haplophragmoides, Reophax, and Trochammina; and 1 each of Gaudryina, Proteonina, Hyperammina, Lituotuba, Verneuilina, and Textularia.

The microfauna is Lower Cenomanian (basal Upper Cretaceous) in age, determined by the associated ammonites Acanthoceras, Pulchellia (?) sp., and Beudanticeras (?).

Three microfaunal assemblages are established: a lower Haplophragmoides fauna from within a fish scale sand zone immediately overlying the Lower-Upper Cretaceous boundary; a Trochammina fauna well expressed 370 feet above the base of the fish scale sand zone; and an upper Lituotuba fauna 530 feet above the base of the fish scale sand zone.

The Haplophragmoides and Trochammina faunas are correlated with the base of the upper Sikanni shales of the Sikanni Chief River area, British Columbia, and the Haplophragmoides fauna is correlated with the uppermost part of the Miliammina-Tritaxia zone of the Shaftesbury formation of the Eastern Peace River area, Alberta.

CHAPTER I

STRATIGRAPHIC RELATIONS OF THE FORT ST. JOHN MICROFAUNA

INTRODUCTION

This thesis deals with a microfauna collected from the type area of the Cretaceous Fort St. John group near the site of old Fort St. John, British Columbia, from which the group name was derived. The microfaunal assemblages discussed in this thesis were collected from a Cenomanian or lowermost Upper Cretaceous portion of the Fort St. John shales of the type area.

The term "Fort St. John" as applied to this sequence of strata has had a various history, and it is necessary to trace the development of knowledge concerning the Fort St. John group from the early reconnaissance survey carried out by Selwyn in 1875 to the present day.

Part I. THE FORT ST. JOHN GROUP

EARLY WORK

The original formal naming of the Fort St. John group and subsequent changes are here briefly outlined.

The first geologist to visit the Peace River area was A. R. C. Selwyn of the Geological Survey of Canada (37, pp. 274-296)[1], who, in 1875, did reconnaissance geology along the Peace River from

[1] The number in brackets refers to the reference number and page as listed in the bibliography in the Appendix of this thesis.

Quesnel Mouth to Smoky River. Selwyn provided the first account of the Fort St. John group, of which he said: "From the 'Fork'- Smoky River-up to Dunvegan, and thence to about five miles below Hudson's Hope, the rocks which are exposed along Peace River...consist of dark earthy shales, in parts characterized by numerous bands and septarian nodules of clay ironstone, many of which enclose large ammonites, and they are also associated with sandy calcareous layers holding Cretaceous fossils, among which, a species of inoceramus (Posidonia, auct.) is tolerably abundant, while in the dark argillaceous shales the scales of fishes are frequently observed."

In 1879, G. M. Dawson (12, pp. 99b-126b) carried out a detailed investigation of the Peace River country, including the areas around Pine River, Smoky River, and Peace River at Fort St. John. Dawson subdivided the Cretaceous rocks embracing these areas in the following manner:

1. Upper sandstones and shales with lignite coals (Wapiti River Sandstones).
2. Upper dark shales (Smoky River Shales).
3. Lower sandstones and shales with lignite and true coals (Dunvegan Sandstone).
4. Lower dark shales (Fort St. John Shales).

Thus Dawson first named the Fort St. John formation, defining it as the lower dark marine shales underlying the Dunvegan sandstones.

In 1888, R. G. McConnell (25, pp. 27d-54d) examined outcrops along the Peace River from the mouth of Red River to the Smoky River Forks, but added little to our knowledge of the Fort St. John shale.

F. H. McLearn carried out important work in the Peace River country during the field seasons of 1917, 1918, 1920, and 1922 (26,27,28,29). In 1918, as a result of investigations along Peace, Smoky, and Athabaska Rivers, McLearn published the following table of formations (27, p. 2c):

SYSTEM		GROUP	SMOKY-PEACE SECTION	
CRETACEOUS	UPPER	Montana	Wapiti	
			Upper shale	Smoky River
		Colorado	Bad Heart sandstone	
			Lower shale	
			Dunvegan	
			St. John	
	LOWER	"Lower Cretaceous"	U. Sandstone	Peace River
			M. Shale	
			L. Sandstone	
			Loon River	

Thus McLearn shortened the name "Fort St. John" formation to "St. John" formation. The latter name, however, had previously been assigned to a Middle Cambrian formation in New Brunswick. McLearn limited the St. John formation to strata overlying the Peace River formation and underlying the Dunvegan formation. The following is the description given for the St. John formation in the Smoky and Peace

River areas: "It consists principally of dark, friable, and paper-thin carbonaceous shale, with some ironstone bands and concretions; where the bedding shows it is on a scale of about 2 inches and indicates marine conditions. The top of this formation consists of thin-bedded sandstone and shale which, in places, by increase in thickness of the sandstone layers upwards, shows a gradation into the massive sandstone at the base of the Dunvegan."

In 1917, McLearn (26, pp. 14-21) found a section in the Hudson Hope area which consisted of two thick marine shale sections separated by a sandstone member. Later, in 1922, McLearn (29, pp. 1-46) called the lower shale the "Moosebar" formation, the middle sandstone the "Gates" formation, and the upper shale was referred to as the "St. John" shale.

From 1919 until 1922, work was done in the Peace River area by E. M. Spieker (38,39), J. A. Dresser (14,15), J. C. Gwillim (18), M. Y. Williams (46), J. S. Stewart (40), and J. A. Allan (1). However, these geologists introduced no new stratigraphic terms.

In the summer of 1929, R. L. Rutherford (36) carried out a water resources survey in the Peace River and Grande Prairie districts. Rutherford examined the St. John formation at Shaftesbury Settlement opposite the mouth of the Smoky, on Smoky River, and the area around Montagneuse River. Rutherford described the St. John formation as consisting mostly of dark to grey, thin-bedded marine shales containing layers of ironstone nodules and concretions. The following sequence of

strata was given for the Eastern Peace River area:

Wapiti formation

Smoky River formation

(Upper shale

(Bad Heart Sandstone

(Lower shale (Kaskapau)

Dunvegan formation

St. John formation

Peace River formation

Loon River formation (at depth)

In 1931, L. S. Russell carried out a survey of the Eastern Peace River area, and a preliminary map of this area was published by the Geological Survey of Canada (35). Russell made a significant change in terminology by re-introducing the term "Fort St. John formation" for the marine shales underlying the Dunvegan formation and overlying the Peace River formation. The following table of formations was included on Russell's map:

Upper Cretaceous

Wapiti formation

Dark marine shale)

Bad Heart formation) Smoky group

Kaskapau formation)

Dunvegan formation

Lower Cretaceous

Fort St. John formation

Peace River formation

Loon River formation

In 1943, Wickenden and Shaw (45) of the Geological Survey of Canada published a paper on the stratigraphy and structure in the Mount Hulcross-Commotion Creek area of British Columbia, in which they raised the Fort St. John from formational to group rank to include the following formations:

Fort St. John group
- Cruiser formation
- Goodrich formation
- Hasler formation
- Commotion formation
- Moosebar formation

In 1944, McLearn and Henderson (31) of the Geological Survey of Canada carried out a detailed survey of the Lone Mountain area, British Columbia, with the result that the name "Shaftesbury" was proposed "for the formation lying between the Peace River and Dunvegan formations in the Eastern part of the Peace River Valley between Dunvegan and the town of Peace River". The Shaftesbury formation in this area was correlated with the Fort St. John formation of the Sexsmith-Bison Lake area (35) and the Hasler, Goodrich, and Cruiser formations of the Mount Hulcross-Commotion Creek area (45).

Beach and Spivak (3), in 1944, included the Moosebar, Gates, Hasler, Goodrich, and Cruiser formations in the Fort St. John group within the Dunlevy-Portage Mountain area, British Columbia.

In 1944, McLearn (32) made a revision of the Lower Cretaceous of the Western Interior of Canada based on lithologic, floral, and faunal evidence. The report included correlation tables showing the

stratigraphic age relationships of the Fort St. John group in the foothills and plains of Western Canada. McLearn assigned an Albian age to the Fort St. John group, with a reservation that the upper part could be of very early Upper Cretaceous age.

Stelck (6a, pp.1-55) recently used microfauna in establishing the Cenomanian-Albian boundary in Western Canada. In his report, Stelck places the lower boundary of the Fort St. John group within the lower part of the Lower Albian sub-stage, and the upper boundary of the Fort St. John group in the lower part of the Middle Cenomanian sub-stage. A correlation table for the Fort St. John group in the Peace River area is outlined on Fig. 1, p. 7a.

LITHOLOGY, THICKNESS, AND DISTRIBUTION

The Fort St. John group consists of a series of sandstone and shale beds, predominantly of marine origin. In the Peace River area of British Columbia, the Fort St. John group overlies the Bullhead group which consists largely of non-marine sandstones, shales, and coal beds. The Fort St. John group is conformably overlain by, and grades into, the predominantly non-marine, deltaic, coaly sandstones and shales of the Dunvegan formation.

In the Fort St. John type area, the Fort St. John group consists of about 2600 feet of dark, predominantly marine shales broken by argillaceous sandy members and overlain by the Dunvegan formation.

Farther east, in the Alberta portion of the Peace River Valley, McLearn (27) and Rutherford (36) assign a total thickness of 1530 feet to the combined Loon River, Peace River, and Shaftesbury

Locality			SIKANNI CHIEF RIVER, B.C.	UPPER PINE RIVER, B.C.	FORT ST. JOHN B.C.	PEACE RIVER, ALBERTA	PEACE RIVER FOOTHILLS, B.C.	FAUNAL ZONES
			DUNVEGAN fmt.	DUNVEGAN fmt.	DUNVEGAN fmt.	DUNVEGAN fmt.	DUNVEGAN fmt.	Unio dowlingi
U. CRETACEOUS	LOWER CEN.	Fort St. John group	Sikanni shales	Cruiser formation	Upper Fort St. John: Fish scale sands	Shaftesbury fmt.: Fish scale sands	"Upper" St. John shales	Acanthoceras
LOWER CRETACEOUS	UPPER ALBIAN	Fort St. John group	Sikanni sandstones	Goodrich fmt.				Neogastroplites
			Buckinghorse formation	Hasler shales				
				Commotion fmt.: Coal member	Peace River fmt.: "Gas-sand" equivalent	Peace River fmt.: Cadotte member		
				Conglomerate		Harmon sh.		Haplophragmoides gigas
	M. ALBIAN			U. Commotion ss. member		Notikewin member		Gastroplites
				M. Commotion ss. member				
				L. Commotion ss. member	Peace River fmt.: Gates member	Peace River fmt.: Monias member	Gates sandstone	
	L. ALBIAN	Fort St. John group		Moosebar shale	Loon River formation	Loon River formation	Moosebar shale	Lemuroceras
			Bullhead sandstone	Bullhead sandstone	Bullhead sandstone	"McMurray" sands	Gething member Bullhead Gr.	Inoceramus dowlingi

Figure 1. TERMINOLOGY OF THE FORT ST. JOHN GROUP IN THE PEACE RIVER AREA

formations of the Fort St. John group. Still farther east, on Athabaska River, the Fort St. John group consists of the Clearwater, Grand Rapids, Joli Fou, Pelican and basal La Biche formations, for which McLearn (26) estimates a thickness of 645 feet for the bottom four formations, while Bahan (1a) includes 95 feet of shales for the basal La Biche formation, giving a total of 740 feet for that area.

Along Pine River, British Columbia, Wickenden and Shaw (45) give the Moosebar, Commotion, Hasler, Goodrich, and Cruiser formations a total thickness of 4800 feet, while in the western Peace River Valley, McLearn (29), Beach, and Spivak (3) give the Moosebar, Gates, Hasler, Goodrich, and Cruiser formations an aggregate thickness of about 3500 feet.

Irish (21,22) found only 400 feet of Fort St. John shales in the Moon Creek and A La Peche map areas, in the northern foothills of Alberta.

Toward the North, along Buckinghorse and Sikanni Chief Rivers, British Columbia, Hage (19) has assigned a total thickness of approximately 4400 feet to the Buckinghorse and Sikanni formations of the Fort St. John group.

On the Alaska Highway, west of Fort Nelson, Williams (47) has noted about 1350 feet of shales and sandstones equivalent to the Fort St. John group.

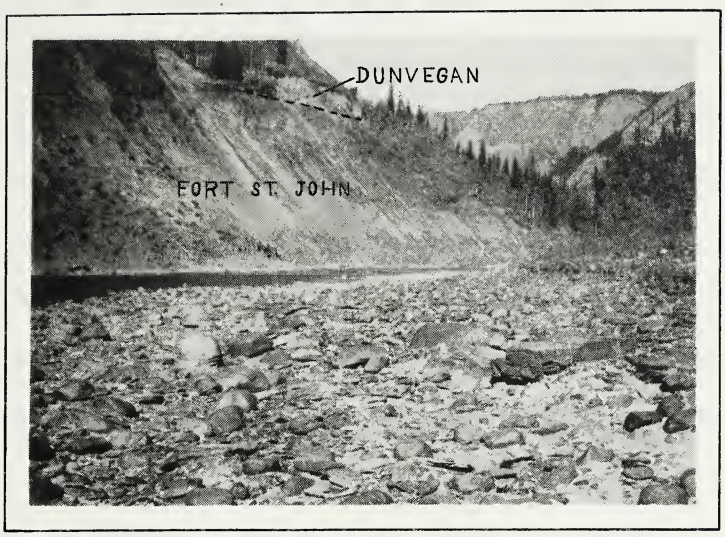
Kindle (23) found the Fort St. John group on the Liard River to consist of the Garbutt, Scatter, and Lepine formations with a thickness of approximately 4500 feet.

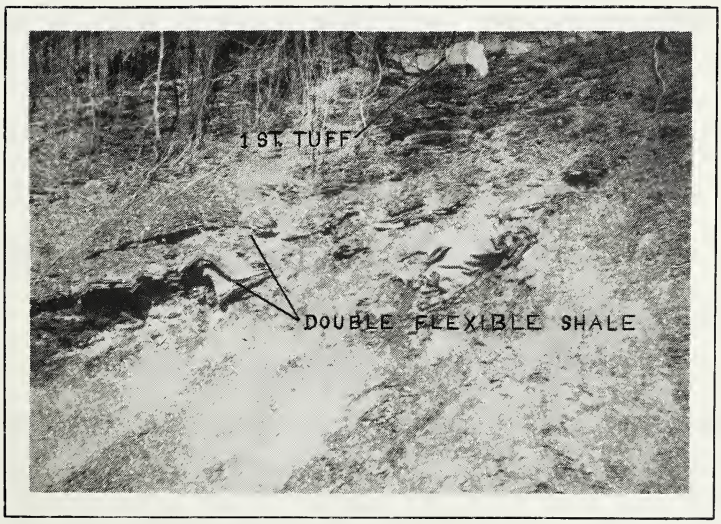
PLATE I

Fig. 1 Beatton River, British Columbia, locality C, showing the Dunvegan sandstones underlain by shales of the Upper Fort St. John group.

Fig. 2 Shale bank of the Upper Fort St. John group on Septimus Creek, British Columbia, locality B, showing the First Tuff and Double Flexible Shale marker horizons.

PLATE I


DUNVEGAN
FORT ST. JOHN


1 ST. TUFF
DOUBLE FLEXIBLE SHALE

The type section of the Fort St. John group at Fort St. John, British Columbia, is represented in outcrop only by strata equivalent to the upper part of the Shaftesbury formation. The Shaftesbury formation and its equivalents show approximately the same pattern of distribution as the Fort St. John group itself. Thus the Shaftesbury and its equivalents have an approximate thickness of 600 feet in the eastern Peace River area, 1200 feet in the Pouce Coupe area, 2000 feet in the Hudson Hope area, 2150-2700 feet in the Commotion Creek area, 2200 feet in the Wapiti River area, and 400 feet in the A La Peche and Moon Creek areas.

A cursory inspection of the Fort St. John group reveals a considerable thickening of the group toward the northwest, west, and southwest, with thinning and pinching out toward the east and southeast. Fort St. John sediments appear to have been deposited in a boreal sea, the exact extent of which is still indefinite. The recent intensive oil well drilling program in Western Canada, and particularly in the Peace River area, will undoubtedly add much to our present knowledge of the Fort St. John Group.

PALAEONTOLOGICAL ZONATION OF THE FORT ST. JOHN GROUP

Correlation of the Fort St. John group is based primarily on the occurrence of beds carrying *Lemuroceras*, *Gastroplites*, *Haplophragmoides gigas*, and *Neogastroplites* faunas. The stratigraphic position of these faunas in the Peace River area is shown in Fig. 1, p. 7a. These Fort St. John faunas have been discussed by McLearn (32)

and Stelck (6a, pp. 5-15), and are here briefly outlined.

The Lemuroceras fauna provides an important means of correlating strata within the Fort St. John group, and has been collected in the lower part of the Buckinghorse formation in the Sikanni Chief River area, British Columbia; in the uppermost Moosebar and lowermost Gates formations in the Peace River foothills, British Columbia; in the upper Loon River and Monias member of the eastern Peace River area, Alberta; and the upper part of the Clearwater formation on Lower Athabaska River, Alberta. Lemuroceras has been recorded from India and Madagascar, and in the latter locality is associated with ammonites of Albian age. In Western Canada, the Lemuroceras fauna marks the Lower Albian-Middle Albian boundary (6a, p. 15).

The Gastroplites fauna permits accurate correlation within the Fort St. John group. Gastroplites cantianus Spath has been found in the uppermost subzone of the Middle Albian of the English Gault, and in the "Upper St. John shales" near the Gates, British Columbia (6a, p. 14). Thus the Gastroplites fauna represents the top of the Middle Albian within the Fort St. John group.

Haplophragmoides gigas has been found within the base of the Colorado shale in southern Saskatchewan; within the lower part of the Colorado (Lloydminster) shale in the Vermilion-Lloydminster area, Alberta; below the Viking sand and above the Mannville formation in the Leduc, Viking, Redwater, and Wabamun areas, Alberta; and within the Harmon member of the Peace River formation in the eastern Peace River

area, Alberta (Stelck, pers. com.). The Haplophragmoides gigas fauna is regarded as lowermost upper Albian in age (6a, p. 47).

Correlations within the upper part of the Fort St. John group are based primarily on the presence of a Neogastroplites fauna in the upper Fort St. John formation in the Fort St. John area, British Columbia.

In 1875, Selwyn (37) first collected a Neogastroplites fauna from the north bank of the Peace River between Cache Creek and Fort St. John trading post, British Columbia. Selwyn collected several ammonites and pelecypods and noted the presence of numerous fish scales. The ammonites were described by Whiteaves (42) as Buchiceras cornutus, which species was later used by McLearn (30) as the genotype of Neogastroplites.

The Neogastroplites fauna collected by Selwyn included Neogastroplites cornutus (Whiteaves), Neogastroplites selwyni (Whiteaves), Nucula dowlingi (McLearn), and Posidonia nahwisi (McLearn). Neogastroplites has since been collected from several sections in the Peace River area. Neogastroplites cf. cornutus has been found in the 3rd. sandstone member of the Sikanni formation. Stelck has collected Neogastroplites sp. and Posidonia nahwisi from Shaftesbury shales in the Wapiti River area, Alberta and British Columbia, and in the Kakwa-Upper Copton area, Alberta. Neogastroplites occurs in the Goodrich formation of the Pine River area, British Columbia, and the topotype region in the Fort St. John area, where it occurs immediately below a Holcolepis fish scale fauna. Neogastroplites has not to date (1951) been found in the Shaftesbury type area of eastern Peace River, Alberta,

but its position is placed at the base of a Holcolepis fish scale horizon in that area.

Definite dating of the Neogastroplites fauna is difficult, because Neogastroplites has not been found outside northwestern Canada. However, in the Pine River area, British Columbia, a species of Pleurohoplites occurs at the top of the Neogastroplites zone in the Goodrich formation. Inasmuch as Pleurohoplites is the European zone fossil for the uppermost Albian, the upper Cretaceous-lower Cretaceous boundary has been placed at the top of the Neogastroplites zone (6a, pp. 14,52). On the strength of the above evidence, the upper Cretaceous-lower Cretaceous boundary within the Fort St. John group has been placed at the top of the Sikanni sandstones in the Sikanni Chief River area, British Columbia; at the top of the Goodrich formation in the Upper Pine River area, British Columbia; immediately below the fish scale sands in the Fort St. John area, British Columbia, and within the fish scale sands of the Shaftesbury formation in the eastern Peace River area, Alberta.

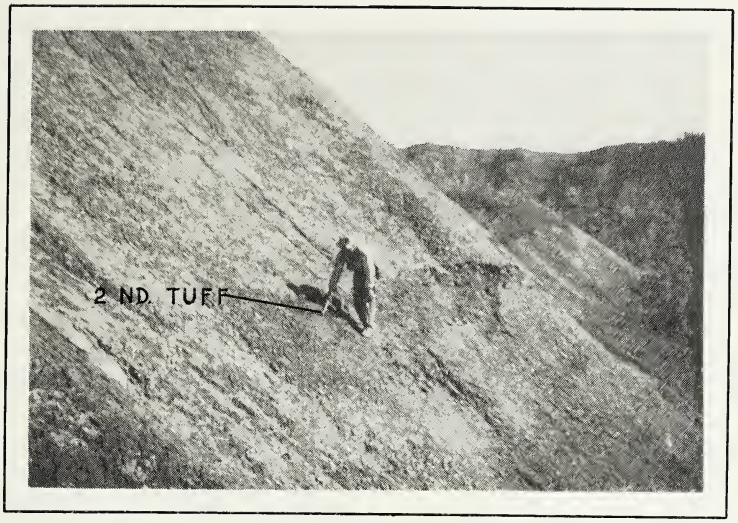
Several species of Acanthoceras have been found in the Lower La Biche shale on Athabaska River, Alberta, and in shales immediately above the Neogastroplites zone in the Fort St. John area, British Columbia (Stelck, pers. com.). Acanthoceras is a Cenomanian zone fossil of the European chronology, thus dating the beds above the Neogastroplites zone of the Fort St. John group as Upper Cretaceous.

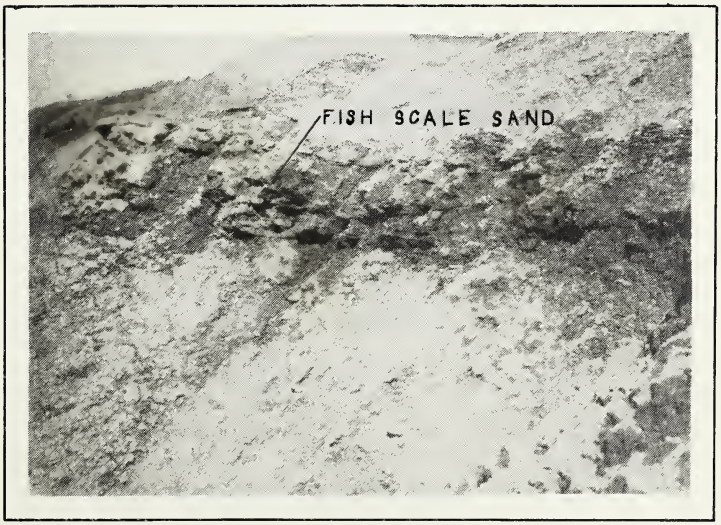
PLATE II

Fig. 1 Shale bank of the Upper Fort St. John group on Peace River, British Columbia, one-half mile downstream from the site of Fort St. John trading post, showing the poor expression of the Second Tuff marker horizon.

Fig. 2 Shale bank of the Upper Fort St. John group on Peace River, British Columbia, one-half mile downstream from the site of Fort St. John trading post, showing the fish scale sand marker horizon.

PLATE II


2 ND. TUFF


FISH SCALE SAND

PART II. LOCAL LITHOLOGY OF THE FORT ST. JOHN GROUP

The shale samples from which the writer's microfaunal suites were extracted were obtained from the type area of the Fort St. John group in the Fort St. John area, British Columbia. The Fort St. John group in this area is represented by a series of predominantly marine shales. The Upper Fort St. John shales are conformably overlain by, and grade into, the deltaic Dunvegan formation.

The following lithologic succession from the Fort St. John area will serve as an outline for the calibration of local descriptions found in the appendix of this report.

Dunvegan formation

Upper Fort St. John formation

Shale, sandy	100'
Cone-in-cone horizon	5"
Shale	250'
Tuff bed (First Tuff horizon)	6"
Shale	8'
Double Flexible shale horizon	3'
Shale	88'
Tuff bed (Second Tuff horizon)	8"
Shale, with fish scales	270'
Fish-scale sands	4'
Shale (Neogastroplites zone)	6'

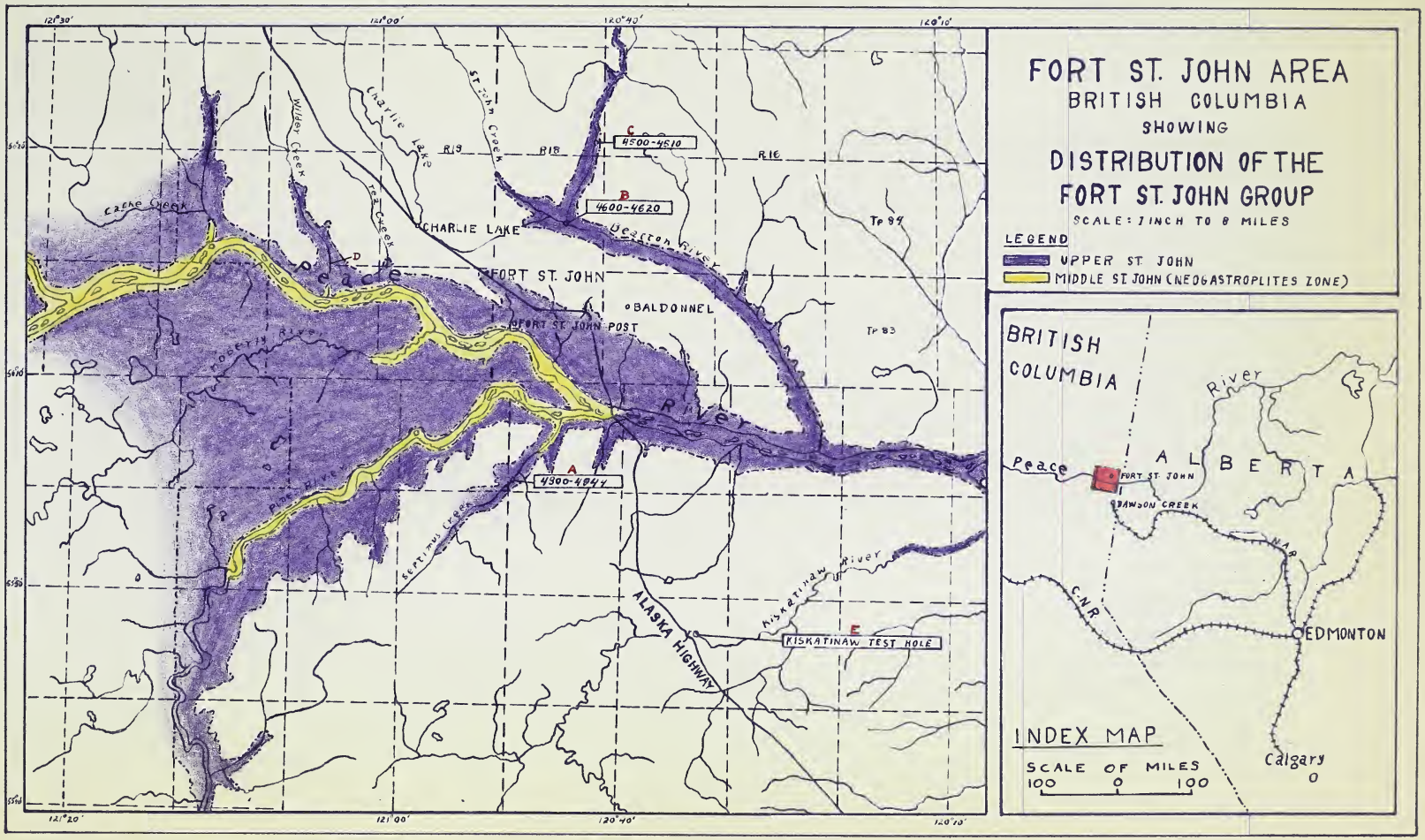
The cone-in-cone, First Tuff (Plate I, Fig. 2), double flexible shale (Plate I, Fig. 2), Second Tuff (Plate II, Fig. 1), and fish scale sands (Plate II, Fig. 2) are distinctive horizon markers, and with the Neogastroplites zone form the bases for mapping the Fort St. John formation in the type area. These marker horizons will be frequently referred to in this thesis.

A detailed description of some sections of the Fort St. John group in the Fort St. John area is included in Part II of the appendix of this report, covering the interval between the Dunvegan formation and the Neogastroplites zone.

The following map shows the distribution of the Fort St. John group in the type area, British Columbia.

OCCURRENCE OF MICROFAUNAS

Lower Cenomanian species of Acanthoceras, Pulchellia (?) sp., and Beudanticeras (?) occur above the uppermost Albian Neogastroplites fauna up to a horizon about 50 feet above the First Tuff horizon of the Fort St. John shales in the Fort St. John area, British Columbia (Stelck, pers. com.). The microfauna discussed in this thesis was collected from beds of these ammonoid zones, thus dating the microfauna as Lower Cenomanian in age.


FORT ST. JOHN AREA
BRITISH COLUMBIA
SHOWING
DISTRIBUTION OF THE
FORT ST. JOHN GROUP
SCALE: 1 INCH TO 8 MILES
LEGEND
UPPER ST. JOHN
MIDDLE ST. JOHN (NEOGASTROPLITES ZONE)
121°30'
121°00'
120°40'
120°10'
R19
R18
R16
Tp 84
Tp 83
Charlie Lake
St John Creek
Miller Creek
Cache Creek
Peace
Pouce Coupe River
Beatton River
CHARLIE LAKE
FORT ST. JOHN
BALDONNEL
FORT ST. JOHN POST
River
Pine River
Septimus Creek
Kiskatinaw River
ALASKA HIGHWAY
KISKATINAW TEST HOLE
A
4900-4844
B
4600-4620
C
4500-4510
D
E
BRITISH COLUMBIA
River
Peace
ALBERTA
FORT ST. JOHN
DAWSON CREEK
NAR
C.N.R.
EDMONTON
Calgary
INDEX MAP
SCALE OF MILES
100 0 100

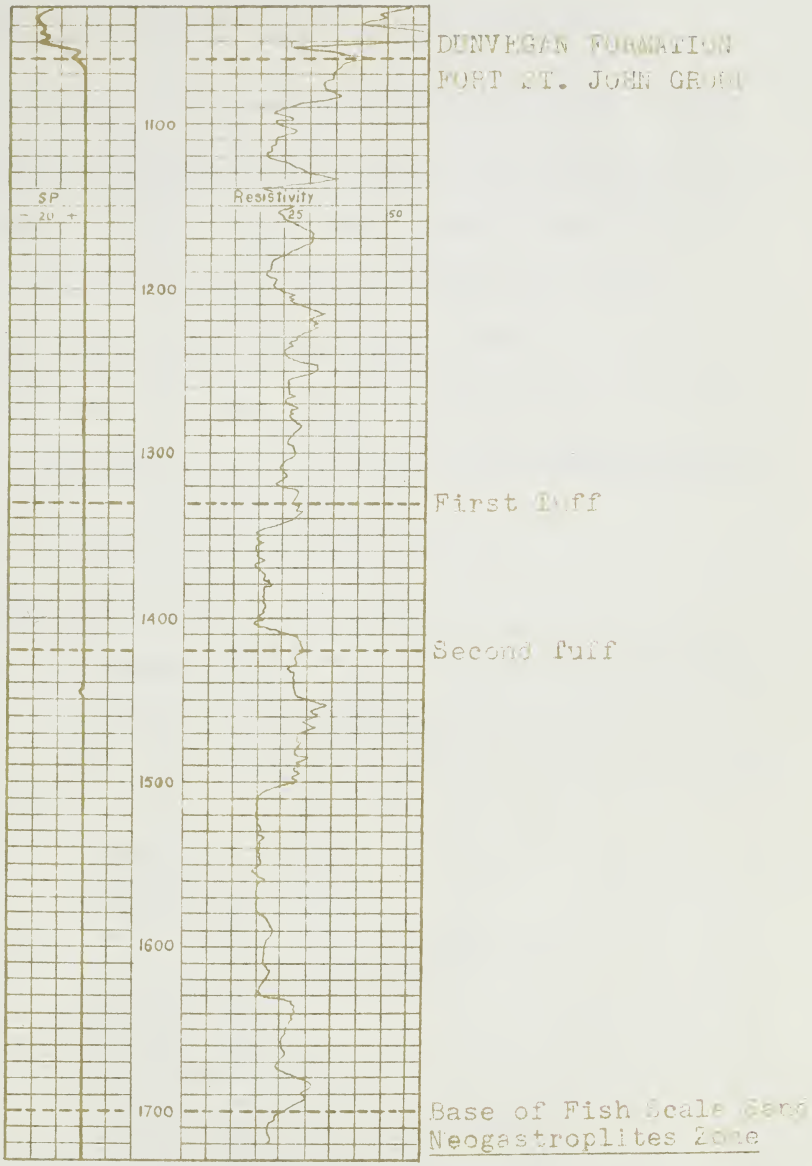


Figure 2: Electric log of part of Pacific Sunrise No.1 Well, Sec.29, Tp.79, R.17, W6th. meridian, British Columbia, showing the good expression of the Fish Scale Sand, and the position of the First Tuff, Second Tuff, and Neogastroplites zone.

CHAPTER II

CENOMANIAN MICROFAUNA OF THE FORT ST. JOHN GROUP

Three main Foraminiferal assemblages are established: a lower Haplophragmoides 4904-A fauna within the fish scale sand zone; a middle Trochammina 4615-A fauna within the Double Flexible shale beds 370 feet above the base of the fish scale sand zone; and an upper Lituotuba 4500-C fauna within the silty shales 530 feet above the base of the fish scale sand zone. In addition, a depauperate fauna occurs within a Pulchellia (?) sp. zone between the Haplophragmoides 4904-A and Trochammina 4615-A faunas.

HAPLOPHRAGMOIDES 4904-A FAUNA

The Haplophragmoides 4904-A fauna from within the fish scale sand zone immediately below the Acanthoceras-bearing beds includes the following species, some of which are illustrated on Plate III of this thesis:

Ammobaculites 4901-B
Ammobaculites 4901-C
Ammobaculites 4902-A
Ammobaculites 4902-B (undescribed)
Ammobaculites 4901-H (undescribed)
Haplophragmoides 4904-A
Reophax 4901-K
Reophax 4901-D
Textularia 4902-C
Verneuilina 4901-E
Hyperammina 4900-D (undescribed)
Tritaxia 4900-K (Ref. 6a, p. 163)
Proteonina 4901-F
Miliammina (?) (undescribed)

Most of the Foraminifera listed above are moderately coarse-grained arenaceous forms closely related to a fauna described by

Stelck from the base of the upper Sikanni shales on Sikanni Chief River, British Columbia.

The lowermost part of the Haplophragmoides 4904-A fauna at the base of the fish scale sand zone is degenerate, consisting of a few specimens of Hyperammina, Tritaxia, Textularia, and Miliammina (?). This basal assemblage grades rapidly into the Haplophragmoides 4904-A fauna proper, which is a prolific assemblage dominated by three species of Ammobaculites, two species of Reophax, and Haplophragmoides 4904-A itself. The latter species makes its initial appearance somewhat later than Ammobaculites and Reophax, and is the dominating form within the upper half of the Haplophragmoides fauna.

Most of the Haplophragmoides fauna is restricted to the fish scale sands, with only a few forms closely resembling Proteonina 4901-F and Haplophragmoides 4901-L continuing on up to the Trochammina 4615-A fauna.

MICROFAUNA OF THE PULCHELLIA (?) sp. ZONE

The Pulchellia (?) sp.-bearing beds between the Haplophragmoides 4904-A and Trochammina 4615-A faunas contain a depauperate fauna dominated by Proteonina and Haplophragmoides, with rare specimens of Tritaxia and Hyperammina. Rare calcareous Foraminifera, identified as species of Gumbelitria and Marginulina, are sporadically distributed throughout this interval. A notable feature of this interval is the restricted appearance of the Radiolarian genus Theocyrtis (?) immediately above the Second Tuff horizon.

Fish scales are present in varying quantities throughout most of

the interval between the base of the fish scale sand and the Trochammina fauna, but are most abundant within the interval 0-90 feet above the base of the fish scale sand zone, and within and near the Double Flexible shale beds. Washed samples from the Double Flexible shales are commonly composed of nearly ninety percent of comminuted fish scales.

Plant fructifications (4a) commonly referred to as "spores" were encountered in varying quantities in most of the suites examined, particularly between the Haplophragmoides 4904-A and Trochammina 4615-A faunas. "Spores" are rare or absent within the Haplophragmoides 4904-A, Trochammina 4615-A, and Lituotuba 4500-C faunas. Within one sample fifty-eight feet above the base of the fish scale sand zone, "spores" are very abundant, and constitute a "spore" horizon.

TROCHAMMINA 4615-A FAUNA

The Trochammina 4615-A fauna is a distinctive fauna best expressed within the Double Flexible shale beds 370 feet above the base of the fish scale sand zone. This fauna is partially illustrated on Plate III of this thesis, and includes the following species:

Trochammina 4615-A
Miliammina 4614-A
Miliammina 4614-B
Lituotuba (?) (undescribed)

Most of the fauna listed above is closely related to a fauna described by Stelck from the base of the upper Sikanni shales on Sikanni Chief River, British Columbia.

Of the above species, Trochammina and Miliammina appear for the first time near the base of the Double Flexible shale beds, and show a

fairly sharp maximum development in numbers near the central portion of the Double Flexible shale beds.

The Trochammina 4615-A fauna is very poorly preserved above the Double Flexible shale up to the First Tuff, often rendering positive identification impossible. Most of the specimens present suggest Lituotuba, with a few Miliammina and ferruginous casts of Trochammina.

A fauna recovered from cores of the Kiskatinaw Test Hole of locality E may be included with the Trochammina 4615-A fauna of the Double Flexible shale beds.

This fauna, illustrated on Plate III of this thesis, includes the following species:

Trochammina 4201-A
Gaudryina 4201-B
Nodosinella 4201-C

The most characteristic species of this suite is Trochammina 4201-A, which is almost identical to Trochammina 4615-A of the Double Flexible shale beds.

LITUOTUBA 4500-C FAUNA

The silty shales within the interval 117-190 feet above the First Tuff horizon and 530 feet above the base of the fish scale sand zone contain a poorly preserved Lituotuba 4500-C fauna.

The Lituotuba fauna includes the following species, a number of which are illustrated on Plate III of this thesis:

Lituotuba 4500-C
Haplophragmoides 4501-A
Hyperammina 4500-A
Miliammina 4506-A
Miliammina 4505-A
Nodosinella 4502-A
Nodosinella 4501-B
Verneuilina 4500-B (undescribed)

The fauna designated as the Lituotuba 4500-C fauna is a distinctive new fauna dominated by Lituotuba, with genera other than Lituotuba and Miliammina poorly developed throughout. Lituotuba is fairly abundant throughout most of the suites, but in the uppermost part of this section shows an apparent decline which is taken up by Miliammina.

Hyperammina, Nodosinella, and Verneuilina are poorly developed in numbers, and are restricted to the lowermost part of the Lituotuba fauna.

PALAEOECOLOGY OF MICROFAUNAS

In the Fort St. John area, British Columbia, the ammonite Neogastroplites occurs with deep-water ammonites immediately below the fish scale sand zone. The Fort St. John sea was widespread immediately prior to Neogastroplites time, as indicated by the known extent of contemporaneous sediments. During Neogastroplites time, the nearest shoreline was at least 60 miles from Fort St. John, and the known distribution of later Fort St. John sediments indicates that these offshore conditions continued well above the fish scale sand zone in the Fort St. John area.

Immediately above the Neogastroplites zone in the Fort St. John area, the basal portion of the Haplophragmoides 4904-A fauna at the base of the fish scale sand zone contains a few specimens of Tritaxia, Hyperammina, Textularia, and Miliammina (?). This basal assemblage represents moderately deep, slightly brackish-water conditions. As the sea-bottom of the fish scale sand zone became more silty, this basal assemblage was rapidly replaced by a microfaunal assemblage dominated by Reophax, Ammobaculites, and Haplophragmoides, with lesser

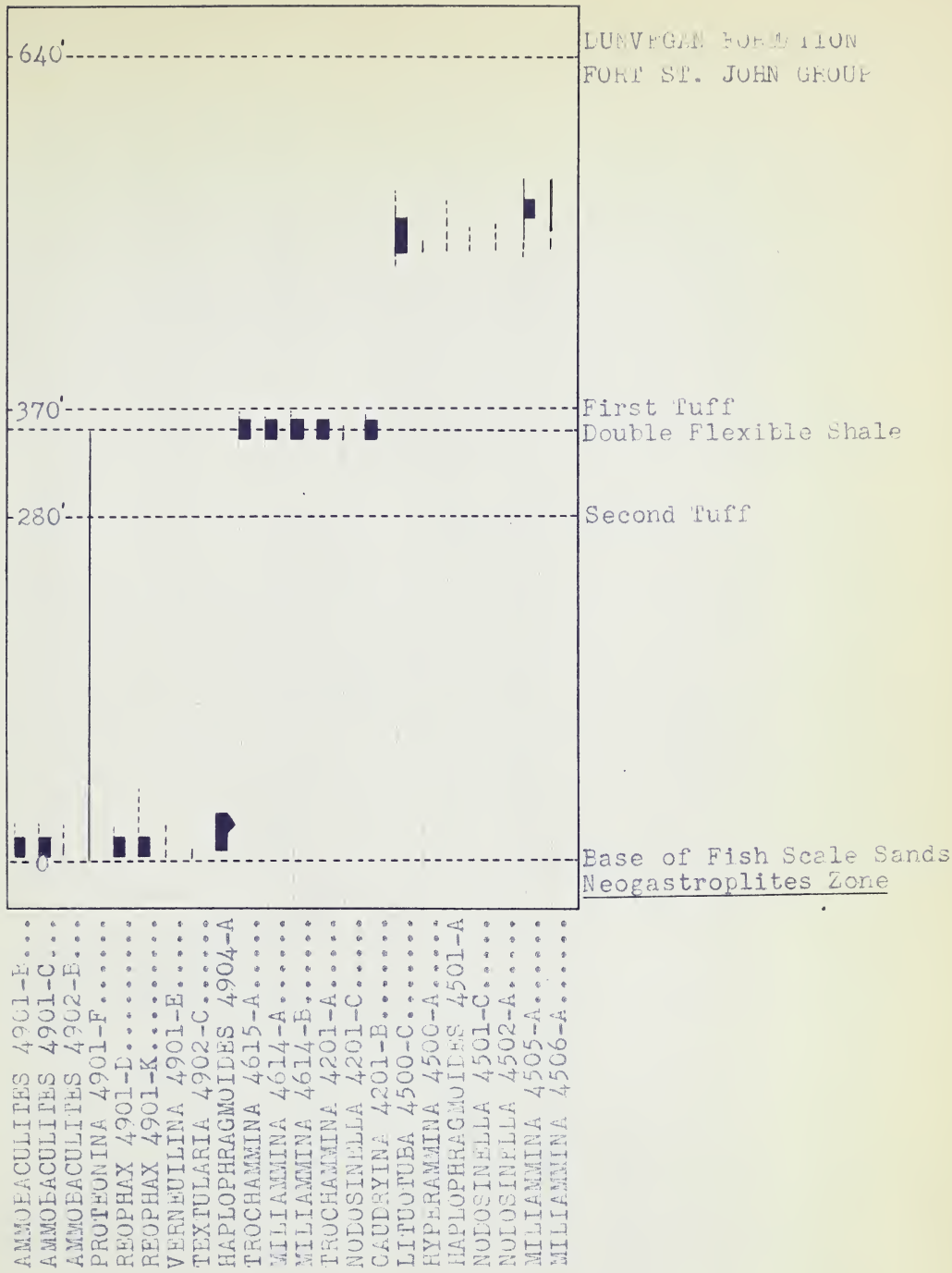


Figure 3: Table showing the vertical distribution of microfauna from the upper part of the Fort St. John group in the Fort St. John Area, British Columbia.

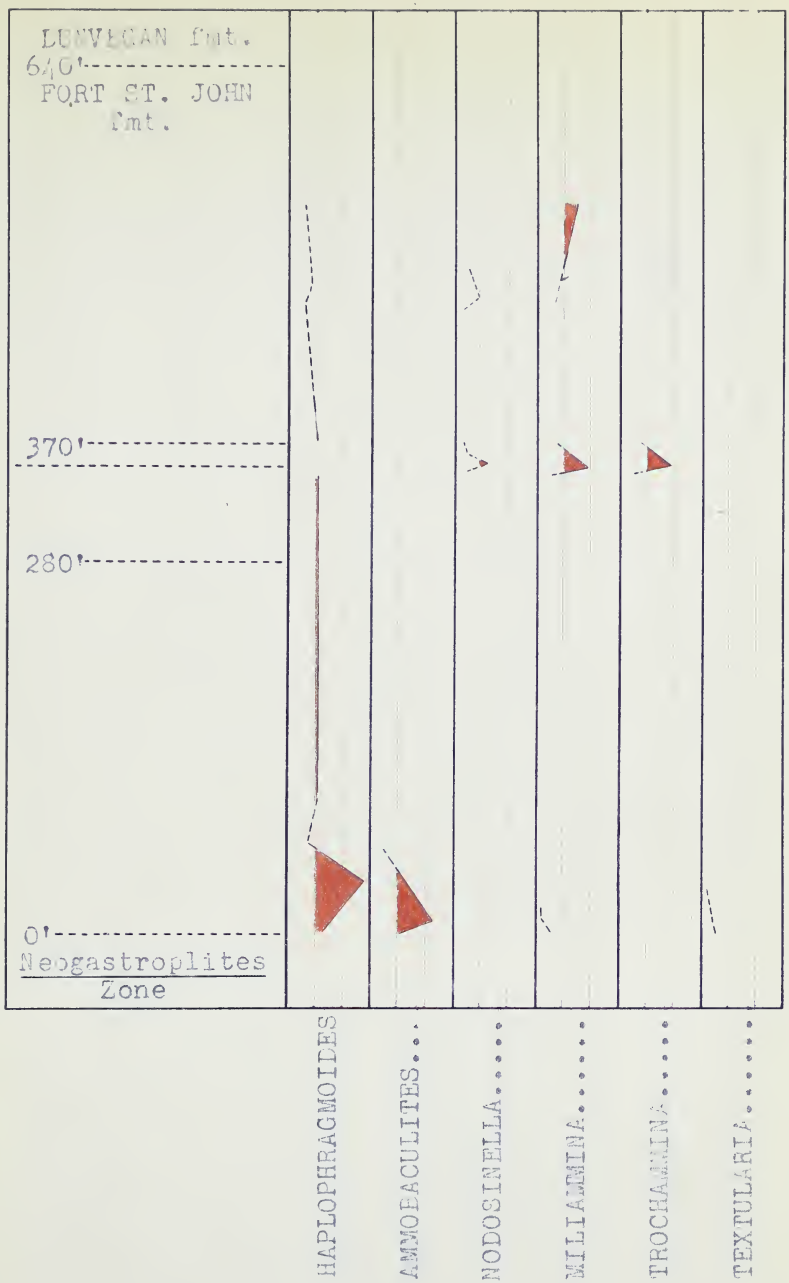


Figure 4: Generic occurrence of Haplophragmoides, Ammobaculites, Nodosinella, Miliammina, Trochammina, and Textularia.

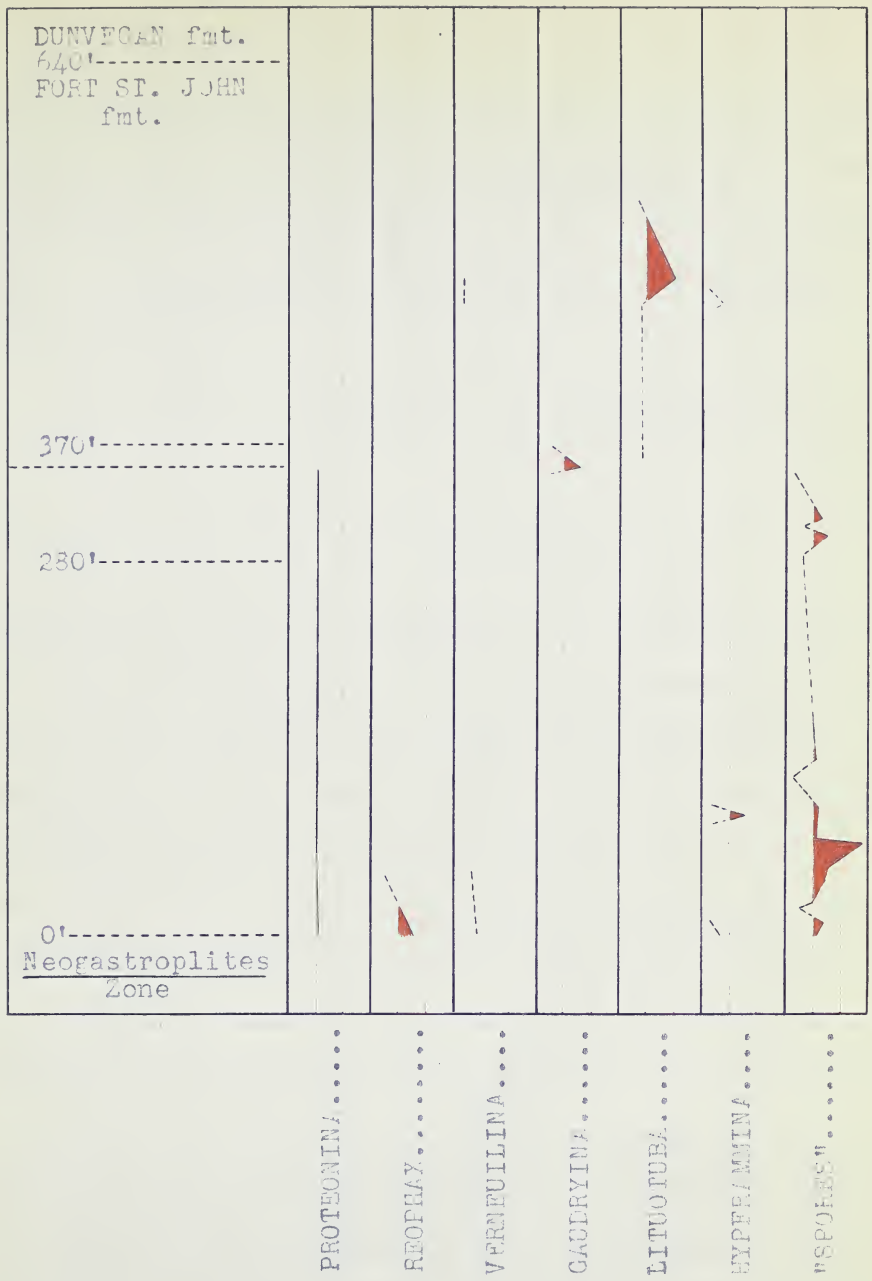


Figure 5: Generic occurrence of Proteonina, Reophax, Verneuilina, Gaudryina, Lituotuba, Hyperammina, and "spores".

numbers of Proteonina and Verneuilina. This microfaunal assemblage indicates that the silt of the fish scale sand in this area was deposited in continuing moderately deep water with brackish tendencies. As deposition of silt subsided, the Haplophragmoides 4904-A fauna rapidly disappeared, with only a few species closely resembling Haplophragmoides 4901-L and Proteonina 4901-F continuing up into the Pulchellia (?) sp.-bearing beds.

The occurrence of Pulchellia (?) sp. and Acanthoceras above the fish scale sands up to the Double Flexible shale indicates that the Fort St. John sea remained moderately deep until the deposition of the Double Flexible shale beds. The microfauna within these Pulchellia-bearing beds is a degenerate fauna dominated by species closely resembling Proteonina 4901-F and Haplophragmoides 4901-L of the fish scale sand zone. Also present within these beds are: Theocyrtis (?), which appears immediately above the Second Tuff horizon; Hyperammina, which occurs briefly 90 feet above the base of the fish scale sands; rare specimens of Gumbelitria and Marginulina; numerous fish scales and spores; and occasional fish bones, fish teeth, and carbonized wood fragments. The occurrence of the Radiolarian genus Theocyrtis (?) immediately above the Second Tuff could be expected considering the increased quantity of silica available, but its occurrence along with other pelagic forms such as Gumbelitria and Marginulina, in association with Pulchellia (?) sp. and Acanthoceras, tends to corroborate the hypothesis that fairly deep-water conditions prevailed at this time. Fish remains, being pelagic, are not especially diagnostic because deposition of this material could take place under diverse

ecological conditions. The occurrence of "spores" and carbonized wood fragments probably represents material transported a considerable distance from land by winds and currents. The moderately deep-water species of Proteonina and Haplophragmoides occur almost continuously from above the fish scale sands to the base of the Double Flexible shale zone, indicating essentially static seas throughout this interval. However, Proteonina and Haplophragmoides, as well as spores, wood fragments, and pelagic Foraminifera suddenly disappear with deposition of the Double Flexible shale beds.

The distinctive Trochammina 4615-A fauna makes its initial appearance at the base of the Double Flexible shale beds, providing a distinct faunal and lithological break. The Double Flexible shale is composed almost entirely of poorly-preserved fish scales cemented with a relatively small amount of mud, which would account for the flexible nature of this shale. Numerous pyrite buttons and fish bones are also present within this flexible shale.

The prolific fauna of the Double Flexible shale is dominated by one species of Trochammina and two species of Miliammina. This is a shallow-water fauna with strong brackish tendencies. The sudden appearance of this fauna, together with the remarkable abundance of fish scales, indicates rapid shallowing of the Fort St. John sea just prior to the deposition of the Double Flexible shale beds. The sea remained static throughout the deposition of the Double Flexible shales, and was fairly widespread, as indicated by the known extent of contemporaneous beds, and by the occurrence of similar faunas in the Sikanni Chief River area, and in the Kiskatinaw Test Hole.

However, after the deposition of the Double Flexible shale beds, the Trochammina 4615-A fauna dwindles and becomes poorly preserved toward the First Tuff horizon, and is absent after the deposition of the First Tuff. Gradually changing ecological conditions, possibly a slow deepening of the sea, is postulated.

An unsampled interval of about 117 feet occurs above the First Tuff horizon, and the fauna encountered immediately above this unsampled interval is the distinctive Lituotuba 4500-C fauna. This is a prolific fauna, but is generally poorly preserved.

The lower part of the Lituotuba fauna is dominated by one or more species of Lituotuba, along with minor numbers of Hyperammina, Haplophragmoides, Nodosinella, and Verneuilina. This is a moderately shallow-water fauna. The lower faunule is gradually replaced by several species of Miliammina toward the upper part of the faunal zone, indicating further shallowing with probable brackish tendencies.

CORRELATIONS

CORRELATION WITH THE SIKANNI CHIEF RIVER AREA, B. C.

Numerous species of the Haplophragmoides 4904-A and Trochammina 4615-A faunas strongly resemble species described by Stelck from the base of the upper Sikanni shales in the Sikanni Chief River area, British Columbia.

The following paired species from the Sikanni shales and the upper part of the Fort St. John shales, though not always identical, show a marked similarity:

Fort St. John Area, B. C.	Sikanni Chief River Area, B. C.
Miliammina 4614-A (Trochammina fauna)	Miliammina 12-202-A (202' above 4th Sikanni ss.)
Trochammina 4615-A (Trochammina fauna)	Trochammina 11-39-E (39' above 4th Sikanni ss.)
Trochammina 4201-A (Trochammina fauna)	Trochammina 11-39-A (39' above 4th Sikanni ss.)
Ammobaculites 4901-B (Haplophragmoides fauna)	Ammobaculites 11-4-C (4' above 4th Sikanni ss.)
Ammobaculites 4901-C (Haplophragmoides fauna)	Ammobaculites 11-56-B (56' above 4th Sikanni ss.)
Reophax 4901-D (Haplophragmoides fauna)	Reophax 12-202-B (202' above 4th Sikanni ss.)
Haplophragmoides 4904-A (Haplophragmoides fauna)	Haplophragmoides 12-133-A (133' above 4th Sikanni ss.)

On the strength of the microfaunal evidence provided above, the base of the upper Sikanni shales in the Sikanni Chief River area, British Columbia, is correlated with the upper part of the Fort St. John shales of the Fort St. John area, British Columbia.

CORRELATION WITH THE EASTERN PEACE RIVER AREA, ALBERTA

Nielsen has reported very poor microfaunal recovery from within and near the fish scale siltstone band (fish scale sands) of the Lower Shaftesbury formation in the Eastern Peace River area, Alberta, but has included this fauna in the uppermost part of his *Miliammina-Tritaxia* fauna (3a). The writer examined Nielsen's microfaunal suites from this zone, and found certain elements in common with the *Haplophragmoides* 4904-A fauna within the fish scale sand zone of the

upper part of the Fort St. John shales of the Fort St. John area, British Columbia.

The following paired species, though not identical, are common to both areas:

Fort St. John Area, B. C.	Eastern Peace River Area, Alberta
Nodosinella 4502-A (Lituotuba fauna)	Nodosinella 31-290-B (290' below base of fish scale sand)
Proteonina 4901-F (Haplophragmoides fauna)	Proteonina 30-142-A (142' below base of fish scale sand)
Ammobaculites 4901-B (Haplophragmoides fauna)	Ammobaculites sp. (4' below base of fish scale sand)
Ammobaculites 4901-C (Haplophragmoides fauna)	Ammobaculites sp. (4' below base of fish scale sand)
Reophax 4901-K (Haplophragmoides fauna)	Reophax sp. (4' below base of fish scale sand)
Verneuilina 4901-E (Haplophragmoides fauna)	Verneuilina sp. (100' above base of fish scale sand)
Haplophragmoides 4904-A (Haplophragmoides fauna)	Haplophragmoides sp. (16' below base of fish scale sand)

On the strength of the above microfaunal evidence, and the stratigraphic relations of both faunas to the fish scale siltstone band (fish scale sands), the Haplophragmoides 4904-A fauna of the upper part of the Fort St. John shales in the Fort St. John area, British Columbia, is correlated with the uppermost part of the Miliammina-Tritaxia zone of the lower Shaftesbury formation in the Eastern Peace River area, Alberta.

CHAPTER III

FORMAL DESCRIPTIONS OF MICROFAUNA

Certain new Foraminifera worthy of description were selected from the microfaunal assemblages recovered from the upper part of the Fort St. John shales. These are here described and illustrated.

All of the Foraminifera described have been specifically designated by a number rather than a name to avoid creation of manuscript names.

The Foraminifera are described in alphabetical and numerical sequence, the number immediately following the generic name indicating the microfaunal suite from which the hypotype was taken.

The stratigraphic positions of all microfaunal suites are shown in Part II of the Appendix of this thesis.

ORDER FORAMINIFERA

GENUS AMMOBACULITES Cushman 1910

Ammobaculites 4901-B

Plate III, Fig. 1

Test robust, earlier portion coiled, involute, showing small slightly depressed umbilical area infilled in part with cement, four chambers in outer whorl of coiled portion, later portion rectilinear with four chambers, the last chamber sub-pyriform in shape but does not tend to become inflated, coiled portion somewhat wider than straight portion; sutures slightly depressed, obscure; wall arenaceous, with considerable cement obscuring the outline of the grains, grains to 0.04mm. in size; aperture terminal, simple, at the end of the last-

formed chamber.

Length of hypotype 0.65mm., diameter of straight portion 0.24mm., diameter of coiled portion 0.28mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales, 1 foot above base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species strongly resembles a species of Ammobaculites described by Stelck from the Sikanni shales four feet above the top of the Fourth Sikanni sandstone on Sikanni Chief River, British Columbia, two miles below the Alaska Highway bridge. The Sikanni species is somewhat finer-grained, with fewer and smaller chambers in the straight portion.

Ammobaculites 4901-C
Plate III, Fig. 2

Test somewhat compressed in early portion, earlier portion close-coiled, showing four chambers in the ultimate whorl, later chambers in slightly curved linear series of four chambers slightly enlarging as added, ultimate chamber slightly pyriform, large, about one-third the length of the entire test; sutures somewhat curved, generally indistinct, last suture depressed, earlier sutures slightly depressed to obscured in the coiled portion; wall coarsely arenaceous, with considerable cement obscuring the smaller grains and only partially obscuring the larger grains, grains to 0.06mm. in size; aperture terminal, simple, at the end of the last-formed chamber.

Length of hypotype 0.55mm., diameter of coiled portion 0.16mm., length of final chamber 0.27mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales, 1 foot above base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species strongly resembles a species of Ammobaculites described by Stelck from the Sikanni shales, 56 feet above the top of the Fourth Sikanni sandstone on Sikanni Chief River, two miles below the Alaska Highway bridge, British Columbia. The Sikanni species is finer-grained, larger, more slender, and has a larger aperture.

Ammobaculites 4902-B
Plate III, Fig. 3

Test compressed in coiled portion, early portion planispiral with tiny umbilicus and consisting of six chambers, later portion uniserial, rectilinear, of three chambers, with the ultimate chamber sub-pyriform in shape, chambers in linear portion fairly distinct, much less distinct in coiled portion; sutures in linear portion fairly distinct, somewhat oblique, slightly depressed, sutures much less distinct in coiled portion; wall arenaceous, with much cement, grains to 0.02mm. in size; aperture terminal, simple, at the end of the ultimate chamber.

Length of hypotype 0.48mm., diameter of coiled portion 0.19mm., diameter of umbilicus 0.04mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales, 3 feet above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles Ammobaculites bergquisti Cushman and Applin, from the Upper Cretaceous Woodbine formation of Texas, but differs in that the former is coarser-grained, smaller, and has only a suggestion of a neck.

GENUS GAUDRYINA d'Orbigny, 1839

Gaudryina 4201-B

Plate III, Figs. 33, 34

Test small, slightly tapering, triserial in early portion, bisèrial, twisted in later portion, consists of about five chambers terminating abruptly in triserial portion, about seven chambers in the biserial portion, gradually increasing in size as added, chambers distinct, slightly inflated; sutures distinct, depressed; wall finely arenaceous, mostly cement, grains about 0.01mm. in size; aperture a high arched slit at the base of the apertural face of the last chamber.

Length of hypotype 0.34mm., maximum diameter 0.14mm.

Hypotype locality: ½ mile downstream from Kiskatinaw River bridge, NE¼ Sec.20, Tp.80, R.17, W6th. meridian, on Alaska Highway, British Columbia, locality E; Upper Fort St. John shales about 450 feet below the base of the Dunvegan formation. Paratype from the same suite.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species is distinctive because of the immediate development of almost the full diameter at the start of the triserial portion. This species resembles Gaudryina painoides Wickenden (1932), from the Boyne beds of Manitoba. The species from the Boyne beds is much smaller, relatively more elongate, and has more chambers. This species also resembles Gaudryina hektori Nauss, from 25 feet above the base of the Lloydminster shale in Northwest Mannville No. 1 Well, Alberta. The Lloydminster species has more chambers and is much larger.

GENUS HAPLOPHRAGMOIDES Cushman, 1910

Haplophragmoides 4501-A
Plate III, Fig. 26

Test small, planispiral, compressed, closely coiled, with umbilical area developed on one side, periphery rounded, chambers fairly distinct, seven or eight chambers visible in the ultimate whorl; sutures indistinct, slightly depressed, straight to slightly curved; wall finely arenaceous with much cement, additional cement in the umbilical area of one side; aperture apparently an opening at the inner margin of the ultimate chamber.

Diameter of hypotype 0.19mm., thickness 0.08mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales about 123 feet above the First Tuff.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles a species of Haplophragmoides

described by Stelck from shales between the Second and Third Sikanni sandstones on Sikanni Chief River, two miles below Alaska Highway bridge, British Columbia. The Sikanni species is slightly smaller, with sutures and chambers more distinct.

Haplophragmoides 4904-A
Plate III, Fig. 32

Test free, planispiral, compressed, involute, tending to become somewhat evolute, periphery sharply rounded, eight chambers visible in the last whorl; sutures somewhat depressed, indistinct, straight to somewhat curved; wall arenaceous, thin and easily crushed, with grains to 0.015mm. in size submerged in much cement obscuring the outline of the grains and producing a smooth frosted appearance on the exterior surface; aperture a low arch at the base of the last-formed chamber.

Long diameter of hypotype 0.42mm., short diameter of hypotype 0.31mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales, 5 feet above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species strongly resembles Haplophragmoides collyra Nauss, from the Clonmel No. 1 Well, Alberta, 400 feet below the top of the Lloydminster shale, but the former is clear and finer-grained, with a frosted smooth exterior surface. The hypotype also resembles a species of Haplophragmoides described by Stelck from

the Sikanni shales 133 feet above the Fourth Sikanni sandstone on Sikanni Chief River, two miles below Alaska Highway bridge, British Columbia. The latter differs in not tending to become evolute in later stages.

GENUS HYPERAMMINA H. B. Brady, 1878

Hyperammina 4500-A
Plate III, Fig. 29,30

Test elongate, compressed, slightly curved, with a small indistinct proloculum and long tubular second chamber open at the outer end, test slightly tapering away from the apertural end, external surface of second chamber crossed by about six irregularly spaced, slightly impressed, oblique transverse lines suggesting growth lines; wall arenaceous, thick, with much cement giving a murky, fairly smooth exterior surface and obscuring the grains; aperture terminal, simple, formed by the open end of the second chamber.

Length of hypotype 0.61mm., maximum width 0.17mm., width of proloculum 0.05mm., length of proloculum 0.03mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales about 117 feet above the First Tuff.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species is distinctive because it has no distinct bulbous proloculum characteristic of the genus. The species resembles the megalospheric form of Hyperammina elegans (Cushman and Waters) from the Pennsylvania of Texas, but has no distinct constrictions

of the second chamber as shown by the latter. The indistinct proloculum of Hyperammina 4500-A resembles that of the Recent species Hyperammina tubulosa Earland, but the latter is larger, thinner-walled, with straight growth rings, and a round aperture.

GENUS LITUOTUBA Rhumbler, 1895

Lituotuba 4500-C
Plate III, Fig. 6,7,8

Test elongate, very variable in shape, usually somewhat flask-shaped, usually of one coil, becoming uncoiled in the adult, composed of an ill-defined proloculum and a long, undivided, tubular second chamber sometimes externally constricted to resemble chambering, the end of the second chamber sometimes tapering toward the apertural end and usually extending beyond the primary coiled position; suture indistinct; wall finely arenaceous, with grains to 0.005mm., with much cement obscuring the chambers and suture and giving the exterior a smooth finish; aperture terminal, simple, formed by the tapered end of the last-formed chamber.

Length of hypotype 0.35mm., maximum diameter of coiled portion 0.11mm., diameter of second chamber 0.06mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales about 117 feet above the First Tuff. Paratypes from the same suite.

Hypotype: University of Alberta Pal. Type. Coll.

Remarks: This species resembles Lituotuba lituiformis H. B. Brady from the Upper Cretaceous of Southeast Trinidad and the Velasco

shale in Mexico, but differs from the latter in being much smoother and less neatly coiled. The extreme variability of this form renders identification uncertain, and there is a possibility that more than one species is present. The generic assignment of this species is also open to question, as there is some indication that it might be a degenerate three-chambered Miliammina because there tends to be a greater constriction of the second tube at the base of the straightened-out portion.

GENUS MILIAMMINA Heron-Allen and Earland, 1930

Miliammina 4505-A
Plate III, Fig. 23,24

Test sub-elliptical, compressed, chambers indistinct, chambers embracing in alternate cyclic arrangement, ultimate chamber becoming much larger toward the apertural end; sutures obscured; wall arenaceous, with well-sorted grains embedded in considerable cement, cement and grains on the exterior surface obscuring the earlier chambers and sutures, grain size to 0.028mm.; aperture terminal, simple, on the rounded end of the last-formed chamber.

Length of hypotype 0.83mm., width 0.45mm., thickness 0.17mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales about 160 feet above the First Tuff.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles Miliammina 4614-B from the Double Flexible shale beds of St. John Creek, locality B, but differs

in that it is much coarser-grained, somewhat larger, has less cement, and the ultimate chamber becomes larger toward the apertural end.

Miliammina 4506-A
Plate III, Fig. 18,19

Test elongate, sub-elliptical, compressed, outer chambers fairly distinct, only last two chambers visible on both sides, ultimate chamber extends past the previous chamber a distance of about one-quarter the length of the test and becomes larger toward the apertural end; sutures indistinct; wall arenaceous, of fairly coarse grains to 0.04mm. in size embedded in much cement, cement obscuring sutures, earlier chambers, and the outline of the grains; aperture terminal, simple, at the end of the last-formed chamber.

Length of hypotype 0.8mm., width 0.31mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales about 166 feet above the First Tuff.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles Miliammina 4505-A from the same locality, but 6 feet lower in the section. However, the former is more slender, with much more cement and coarser grains.

Miliammina 4614-A
Plate III, Fig. 15,16,17

Test somewhat elliptical, outer chambers fairly distinct, chambers in quinquiloculine arrangement, two chambers visible on one side, three visible on the opposite side, apertural end of the last

chamber constricted to form a short neck; sutures indistinct, slightly depressed; wall finely arenaceous with much cement and an outer coating of translucent cement; aperture terminal, simple, a slightly restricted opening at the end of the last-formed chamber.

Length of hypotype 0.62mm., width 0.28mm.

Hypotype locality: Mouth of St. John Creek, Sec.14, Tp.84, R.18, W6th. meridian, British Columbia, locality B; Upper Fort St. John shales in the middle of the Double Flexible shale zone.

Hypotype: lost, paratype in University of Alberta Pal. Type Coll.

Remarks: This species resembles a species of Miliammina described by Stelck from the Sikanni shales, 202 feet above the Fourth Sikanni sandstone on Sikanni Chief River, two miles below Alaska Highway bridge, British Columbia. The Sikanni species is smaller and somewhat finer-grained. The Sikanni species more closely resembles flattened specimens of Miliammina 4614-A.

Miliammina 4614-B
Plate III, Fig.9

Test sub-elliptical, compressed, only the ultimate and penultimate chambers visible on both sides, apertural face slightly oblique, ultimate chamber becoming smaller toward the apertural end; sutures obscured; wall finely arenaceous, with much cement, an extra outer coating of translucent whitish cement obscuring the earlier chambers and sutures; aperture terminal, simple, on the rounded end of the last-formed chamber.

Length of hypotype 0.63mm., width 0.34mm.

Hypotype locality: Mouth of St. John Creek, Sec.14, Tp.84,

R.18, W6th. meridian, British Columbia, locality B; Upper Fort St. John shales in the middle of the Double Flexible shale zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles a species of Miliammina described by Stelck from the middle part of the Dunvegan formation on Peace River, one mile west of the mouth of Hines Creek, Alberta. The Dunvegan species has a flared aperture and is slightly coarser-grained. This species also closely resembles Miliammina 4505-A from 160 feet above the First Tuff at locality C, but the latter is much coarser-grained, slightly larger, and the ultimate chamber becomes larger toward the apertural end.

GENUS NODOSINELLA H. B. Brady, 1879

Nodosinella 4201-C
Plate III, Fig. 35,36

Test small, elliptical, slightly compressed, uniserial throughout, composed of a fairly large proloculum and four later or incipient chambers, maximum width in the equatorial region of the test, proloculum distinct, later chambers weak and indistinct; sutures somewhat depressed, somewhat thickened producing a double-wall effect; wall finely arenaceous with much translucent cement, and an extra outer coating of cement; aperture terminal, simple, round, at the end of the last-formed chamber.

Length of hypotype 0.31mm., maximum diameter 0.19mm.

Hypotype locality: one-half mile downstream from Kiskatinaw River bridge on Alaska Highway, NW¼ Sec.26, Tp.80, R.17, W6th. meridian, British Columbia, locality E; Upper Fort St. John shales about 450 feet below the base of the Dunvegan formation.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: The weak partitioning of the last four chambers of this species suggests exterior constriction rather than chambering. The nature of the last four chambers and the small aperture introduces a possibility that this genus should be assigned to Hippocrepina. This hypotype is similar to the ultimate half of the Recent species Hippocrepina indivisa Parker, and may represent a megalospheric form of the latter genus. The weak chambering of this species is similar to that of Nodosinella 4501-B from 123 feet above the First Tuff on Beatton River, British Columbia, locality C. This hypotype also shows a remarkable resemblance to the Recent species Hippocrepinella hirudinea Heron-Allen and Earland, in shape, wall structure, aperture, and constrictions or wrinkling resembling chambering.

Nodosinella 4501-B
Plate III, Fig. 20,21,22

Test uniserial, tapering rapidly, somewhat compressed, with a small proloculum and four later chambers increasing in size as added, chambers indistinct, at an angle of about thirty degrees to the axis of the test, width of chambers much greater than the length; sutures fairly distinct, thickened giving a double-wall effect, at an angle of about thirty degrees to the axis of the test; wall finely arenaceous, with grains set in a finely arenaceous matrix of grains and cement, surface irregularly pappilate; aperture terminal, large, at the end of the last-formed chamber.

Length of hypotype 0.6mm., maximum width 0.4mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales

about 123 feet above the First Tuff.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: The apparent chambers of this species could be caused by exterior constrictions of the test, in which case it could be assigned to the genus Hyperamminoides. This species resembles the initial portion of the microspheric form of a Pennsylvanian species Hyperamminoides elegans (Cushman and Waters) in wall structure and rapidly tapering test, but differs in that the sutures or constrictions of the former are at an angle to the axis of the test, and the part of the test later than the proloculum appears to be chambered.

Nodosinella 4502-A
Plate III, Fig.31

Test elongate, somewhat compressed, uniserial, consisting of a small offset proloculum and three later chambers, chambers increasing in width to the mid-portion of the test, then tapering slightly toward the apertural end, proloculum distinct, remaining chambers indistinct; sutures curved, thickened, each suture marked by three incipient sub-parallel lineal depressions, only the initial suture distinct; wall finely arenaceous with grains to 0.008mm. in size, much cement giving the exterior a smooth dull finish and obscuring the outline of grains, chambers, and sutures; aperture wide, at the end of the last-formed chamber, about two-thirds the diameter of the ultimate chamber.

Length of hypotype 0.46mm., maximum diameter 0.25mm.

Hypotype locality: Beatton River, Sec.1, Tp.85, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales about 129 feet above the First Tuff.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles a species of Nodosinella described by Nielsen from the lower part of the Shaftesbury formation 290 feet below the fish scale zone on Smoky River, Alberta. The Shaftesbury specimen differs in that it has two more chambers, lacks the distinctive offset proloculum, has a more restricted aperture, and has a thicker wall. The wide aperture of Nodosinella 4502-A is similar to that of Nodosinella 4501-B from the same locality, but 6 feet higher stratigraphically, and appears to belong to the same group. The chambering shown by Nodosinella 4502-A strongly resembles the constrictions of Hippocripina bendensis Harlton, a Pennsylvanian species from Oklahoma.

GENUS PROTEONINA Williamson, 1858

Proteonina 4901-F
Plate III, Fig.5

Test a single bottle-shaped chamber with rounded base, sides almost parallel, slightly tapered elongate neck set at an angle to the test; wall arenaceous, fairly thick, grains embedded in siliceous cement, slightly more cement composing the neck, grain size to 0.046mm.; aperture terminal, simple, round, at the end of an elongate neck.

Length of hypotype 0.35mm., width 0.22mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales one foot above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species is almost identical to a species of Proteonina described by Nielsen from the lower part of the Shaftesbury formation, 142 feet below the middle gypsiferous siltstone band, on Smoky River, below Judah, Alberta. The Shaftesbury species is much

larger and coarser-grained, with a somewhat differently shaped neck. This hypotype shows a suggestion of an incipient second chamber, and could be an immature form of Reophax 4901-K from the same suite. However, Reophax 4901-K has no neck.

GENUS REOPHAX Montfort, 1808

Reophax 4901-D
Plate III, Fig. 4

Test uniserial, tapering, chambers regularly increasing in size as added, five chambers composing the test; sutures slightly depressed, somewhat indistinct; wall arenaceous, of large well-sorted grains to 0.04mm. in size, grains embedded in translucent cement with a thin cement covering, though not obscuring the outline of the grains; aperture terminal, simple, at the end of the last-formed chamber.

Length of hypotype 0.41mm., maximum diameter 0.18mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales, one foot above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species strongly resembles a species of Reophax described by Stelck from the Sikanni shales 202 feet above the Fourth Sikanni sandstone on Sikanni Chief River, two miles below Alaska Highway bridge, British Columbia. The Sikanni species is much larger, with the sand grains of the wall less uniform in size. The last four chambers of this hypotype closely resemble those of a species of Bigenerina described by Stelck from the same locality as Reophax mentioned above, and there is a possibility that this form

could be Bigenerina.

Reophax 4901-K
Plate III, Fig. 37

Test small, uniserial, straight, tapering, composed of four chambers, chambers fairly distinct, increasing in size as added, initial chamber fairly large and bulbous, final chamber large and sub-pyriform; sutures fairly distinct, somewhat depressed, transverse; wall arenaceous, with grains set in much cement, and with an exterior coating of cement subduing the outline of grains, grain size to 0.068mm.; aperture terminal, simple, at the end of the last-formed chamber.

Length of hypotype 0.57mm., maximum width 0.34mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality C; Upper Fort St. John shales one foot above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles Reophax nevini Cole, from the Eocene of Mexico, but the latter differs in being much larger, with more distinct chambers and sutures. This hypotype also resembles an undescribed species of Reophax from 4 feet below the middle gypsiferous sandstone in Nielsen's suites from the lower Shaftesbury formation below Judah Station, Alberta. The Shaftesbury species is somewhat larger, coarser-grained, and does not taper as rapidly.

GENUS TEXTULARIA Defrance, 1824

Textularia 4902-C
Plate III, Fig. 25

Test small, elongate, tapering, biserial, flattened on the biserial side, consisting of two series of alternating chambers with eight chambers in each series, chambers distinct except in the earliest part, gradually increasing in size as added; sutures somewhat indistinct, especially in the initial stages, sutures slightly depressed and limbate; wall finely arenaceous, thin, with evenly-pebbled appearance on the surface; aperture at the inner margin of the last-formed chamber.

Length of hypotype 0.32mm., maximum width 0.03mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales, one foot above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species resembles a species of Textularia described by Stelck from the Kaskapau shales 74 feet below the base of the Inoceramus labiatus zone on Kiskatinaw River, Arras, British Columbia. The Kaskapau species has fewer chambers and is much less slender. The shape of the chambers of this hypotype somewhat resemble Textularia subhaueiri Cushman, from the Upper Cretaceous Byram marl, but the latter is much larger, coarser-grained, and stouter. There is a possibility that the first three chambers of this hypotype are coiled.

GENUS TROCHAMMINA Parker and Jones, 1859

Trochammina 4201-A
Plate III, Fig. 10,11,12

Test trochoid, of three whorls, six chambers in the ultimate whorl, seven chambers in the penultimate whorl, three chambers visible in early whorl, periphery rounded, lobate, chambers increasing suddenly in size at the end of each whorl, chambers distinct, six chambers of the outer whorl visible on the ventral side, additional cement filling tiny umbilicus on ventral side; sutures depressed, radial, slightly thickened; wall finely arenaceous, with evenly sorted grains to about 0.002mm. in size buried in considerable cement, smooth finish of transparent cement on the exterior surface; aperture an arched opening at the base of the terminal face of the ultimate chamber near the umbilical margin; color clear to reddish-brown in some forms of preservation.

Maximum diameter of hypotype 0.37mm., thickness 0.2mm.

Hypotype locality: one-half mile downstream from Kiskatinaw River bridge, on the Alaska Highway, NW¼ Sec.26, Tp.80, R.17, W6th. meridian, British Columbia, locality E; Upper Fort St. John shales about 450 feet below the base of the Dunvegan formation.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: Most of these forms are deformed by compression, only the pyritized specimens retaining their original shape. This species closely resembles Trochammina 4615-A from the Double Flexible shale of locality B, and is a variety of the latter species. This hypotype also resembles a species of Trochammina described by Stelck

from the Sikanni formation, 39 feet above the Fourth Sikanni sandstone on Sikanni Chief River, two miles below Alaska Highway bridge, British Columbia. The Sikanni species has fewer chambers.

Trochammina 4615-A
Plate III, Fig. 13, 14

Test trochoid, with a low spire, somewhat lobate, test composed of three whorls with six chambers visible in the ultimate whorl, four or five chambers in the penultimate whorl, and three chambers in the initial whorl, all chambers visible on dorsal side, chambers of ultimate whorl and part of the penultimate whorl visible on ventral side, chambers increasing quite regularly in size with a sudden increase in size in the ultimate whorl, chambers distinct in the ultimate whorl, indistinct in the earlier whorls; sutures indistinct; wall finely arenaceous, with much cement giving the exterior a fairly smooth dull finish, grain size to 0.002mm.; aperture an arched slit with a suggestion of a lip at the inner margin of the ultimate chamber.

Long diameter of hypotype 0.31mm., short diameter 0.26mm.

Hypotype locality: Mouth of St. John Creek, Sec.14, Tp.84, R.18, W6th. meridian, British Columbia, locality B; Upper Fort St. John shales, Double Flexible shale beds.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: This species is almost identical to Trochammina 4201-A of the Kiskatinaw Test Hole, locality E, and differs in appearance due to severe compression of outcrop specimens. This species is also almost identical to a species of Trochammina described

by Stelck from the Sikanni shales, 39 feet above the Fourth Sikanni sandstone on Sikanni Chief River, two miles below Alaska Highway bridge, British Columbia.

GENUS VERNEUILINA d'Orbigny, 1840

Verneuilina 4901-E
Plate III, Fig. 27,28

Test small, robust, tapering rapidly, triserial throughout, composed of five convolutions of three chambers each, slightly twisted, maximum width at theapertural end of the test, chambers indistinct, increasing fairly rapidly in size as added; sutures slightly depressed, indistinct; wall arenaceous, with grains coated with an outer layer of cement and accentuating the roughness of the surface, grain size to 0.02mm.; aperture an angular arched opening at the base of the final chamber.

Length of hypotype 0.32mm., maximum diameter 0.21mm.

Hypotype locality: Septimus Creek, Sec.20, Tp.82, R.18, W6th. meridian, British Columbia, locality A; Upper Fort St. John shales from one foot above the base of the fish scale sand zone.

Hypotype: University of Alberta Pal. Type Coll.

Remarks: The wall structure of this species resembles Verneuilina polystropha (Reuss) H. B. Brady, from the Upper Cretaceous of Trinidad, but the former has fewer chambers, is more robust, and has a different aperture.

EXPLANATION OF PLATE III

Page

Fig. 1: Ammobaculites 4901-B, x87, hypotype, from upper part of Fort St. John shales, 1 foot above base of fish scale sands, locality A, Septimus Creek, British Columbia; slightly retouched photograph of side view of hypotype..... 25

Fig. 2: Ammobaculites 4901-C, x87, hypotype, from upper part of Fort St. John shales, 1 foot above base of fish scale sand, locality A, Septimus Creek, British Columbia; retouched photograph of side view of hypotype..... 26

Fig. 3: Ammobaculites 4902-B, x87, hypotype, from upper part of Fort St. John shales, 3 feet above base of fish scale sand, locality A, Septimus Creek, British Columbia; retouched photograph of side view of hypotype..... 27

Fig. 4: Reophax 4901-D, x87, hypotype, from upper part of Fort St. John shales, 1 foot above base of fish scale sand, locality A, Septimus Creek, British Columbia; retouched photograph of side view of hypotype..... 40

Fig. 5: Proteonina 4901-F, x87, hypotype, from upper part of Fort St. John shales, 1 foot above base of fish scale sand, locality A, Septimus Creek, British Columbia; slightly retouched photograph of side view of hypotype..... 39

Fig. 6,7,8: Lituotuba 4500-C, x87, hypotype, from upper part of Fort St. John shales, 117 feet above First Tuff, locality C, Beatton River, British Columbia; 6,7, retouched photographs of side views of paratypes; 8, retouched photograph of side view of hypotype..... 32

Fig. 9: Miliammina 4614-B, x35, hypotype, from upper part of Fort St. John shales, Double Flexible shale zone, locality B, mouth of St. John Creek, British Columbia; slightly retouched photograph of side view of hypotype,,..... 35

Fig. 10,11,12: Trochammina 4201-A, x35, hypotype, from upper part of Fort St. John shales, locality E, Kiskatinaw test hole, ½ mile downstream from Kiskatinaw River bridge on Alaska Highway, British Columbia; 10, slightly retouched photograph of ventral view of hypotype; 11, slightly retouched photograph of peripheral view of hypotype; 12, slightly retouched photograph of dorsal view of hypotype..... 43

Fig. 13,14: Trochammina 4615-A, x87, hypotype, from upper part of Fort St. John shales, Double Flexible shale zone, locality B, mouth of St. John Creek, Beatton River, British Columbia; 13, retouched photograph of dorsal view of hypotype; 14, retouched photograph of ventral view of hypotype.. 44

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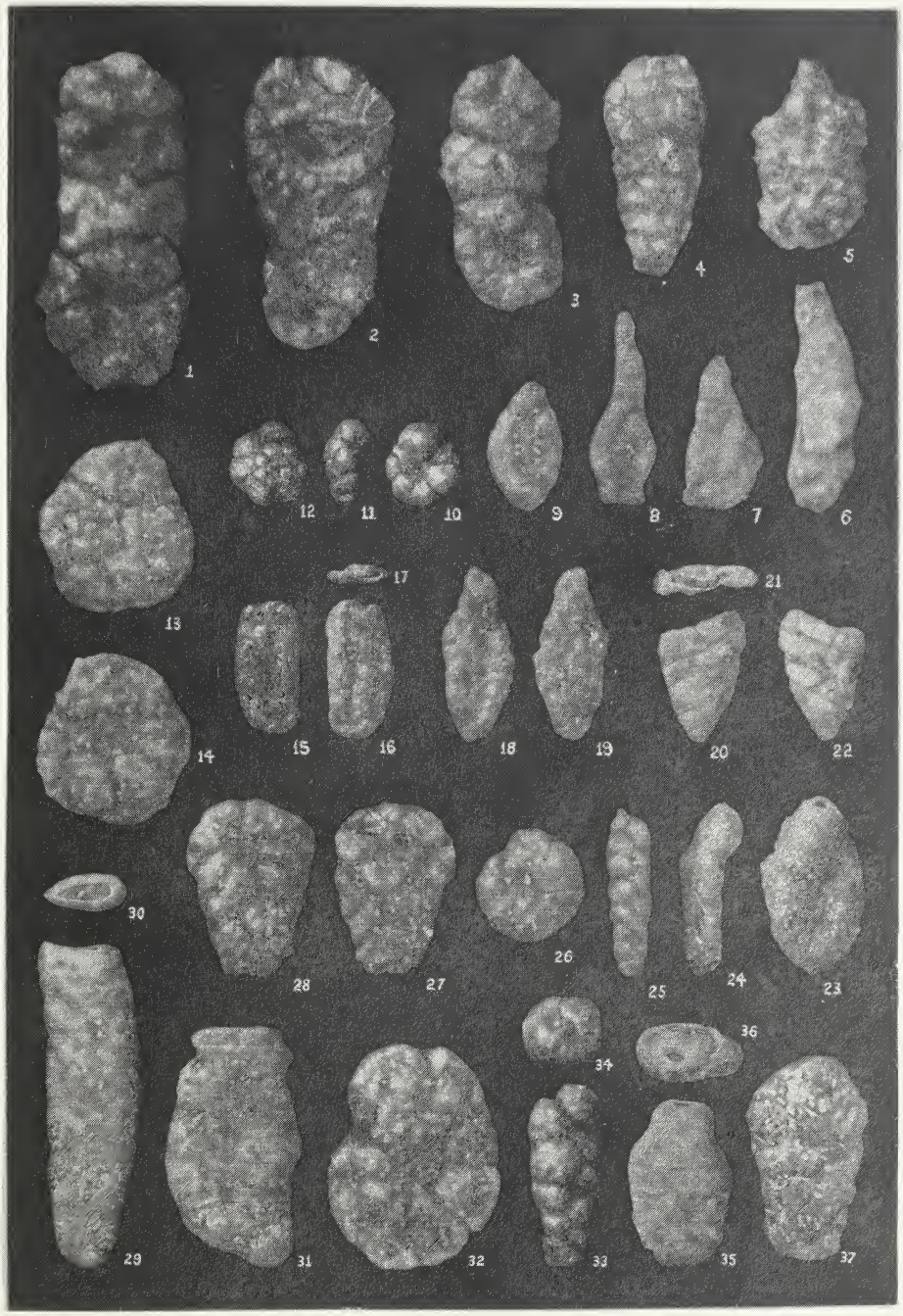
PLATE III

LOWER CENOMANIAN FORAMINIFERA
FORT ST. JOHN GROUP ACANTHOCERAS ZONE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APPENDIX - PART I

TECHNICAL PROCEDURE AND FIELD WORK

FIELD WORK

The samples examined by the writer were collected in the Fort St. John area, British Columbia, by a Pacific Petroleums Ltd. field party during the 1950 field season. The field party consisted of C. R. Stelck, W. G. Bahan, R. Sutherland, J. Ontko, W. Panasiuk, S. Paskevich, E. Rosen, and C. Butler-Stony.

Samples of the Upper Fort St. John formation were collected at locality A by R. Sutherland and J. Ontko on Septimus Creek, B. C., Sec. 20, Tp. 82, R.18, W6th.; at locality B by R. Sutherland at the mouth of St. John Creek, B. C., Tp. 84, R.18, W6th.; at locality C by R. Sutherland and C. R. Stelck on Beatton River, B. C., Sec. 1, Tp. 85, R.18, W6th.; and at locality E by W. G. Bahan from a test hole drilled ½ mile downstream from Kiskatinaw bridge on the Alaska Highway in NW¼ Sec. 26, Tp. 80, R.17, W6th., B. C.

Stratigraphically, samples used by the writer range from the top of a fish scale sand located approximately 690 feet below the base of the overlying Dunvegan formation, to a point approximately 175 feet below the base of the Dunvegan formation. The samples were tied in with several well established horizon markers, which in ascending order include: a fish scale sand immediately overlying a Neogastroplites zone, a tuff bed (Second Tuff), a double flexible shale bed, a tuff bed (First Tuff), and a cone-in-cone bed. Continuity of vertical section

between sampling localities was established by correlation of individual beds and direct measurement of the section between sample points.

The samples were obtained by following a discontinuous sampling procedure. Normally, samples were taken at six-foot intervals, but intervals varied from three to ten feet. A shallow pit was dug at each sampling point and a six-inch section was sampled. Each sample was hand-picked to remove all ironstone matter and hard sandy material. Samples were immediately placed in postal-type cotton bags and were shipped directly to the Department of Geology, University of Alberta, Edmonton, Alberta.

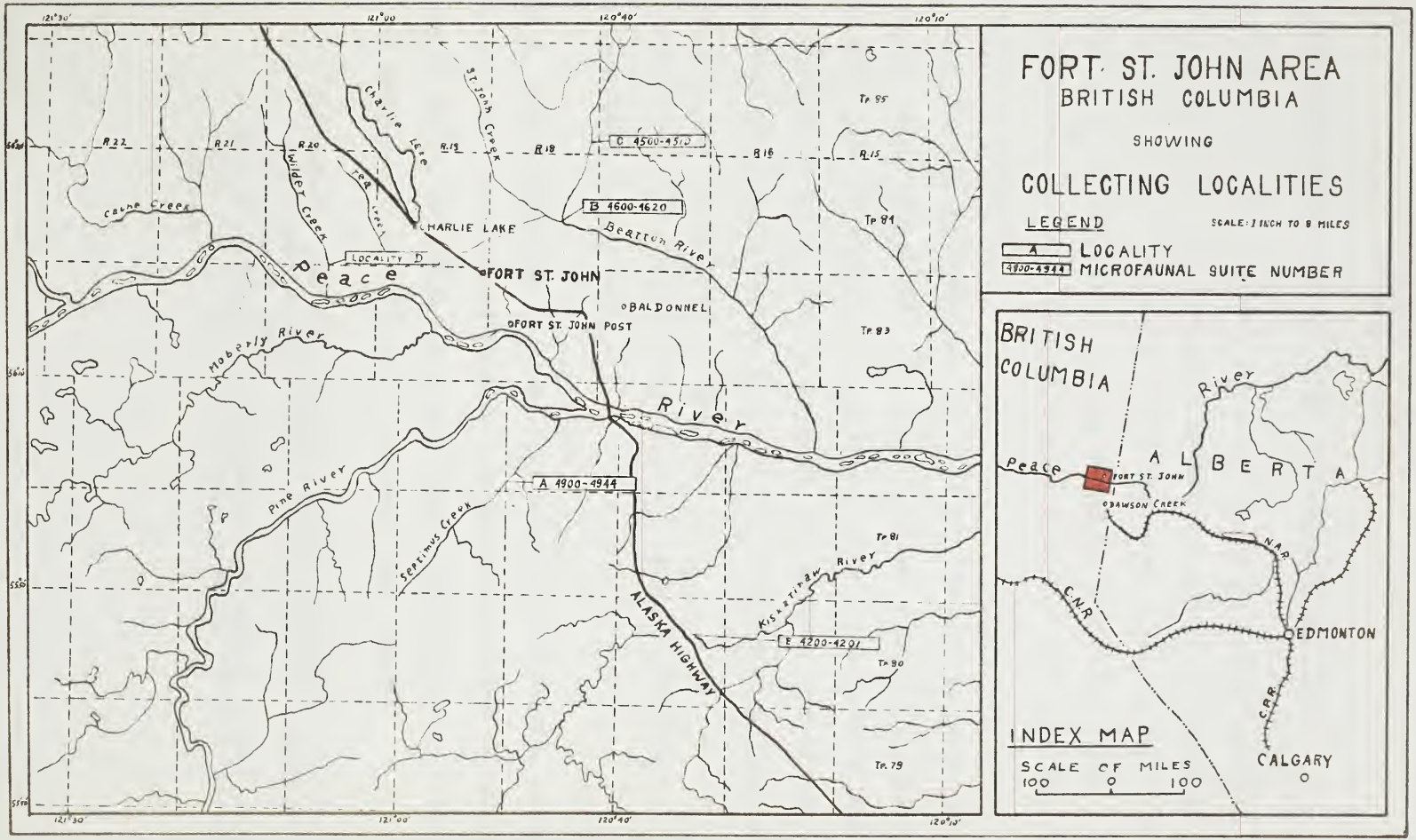
TECHNICAL PROCEDURE

The procedure used in the preparation of microfossils for final study follows the outline given by A. R. Nielsen in his thesis (3a,pp.5-8).

Systematic examination of samples yielded certain morphologic types suitable for description and figuring. One hypotype of each morphologic type was selected and transferred to a single-cell slide. Several paratypes were mounted in the cell with each hypotype.

Specimens were variously orientated and photographed, using Superpan Press film and a Leitz Wetzler M4B camera in conjunction with a Leitz No. 394635 microscope. The films were developed by the writer, using equipment available in the Department of Geology, University of Alberta. A magnification of thirty five times was used throughout. Printing, as well as enlarging wherever required, was done by a commercial firm (Silvertone).

The photographs were retouched, where necessary, to accentuate certain features. Photographs of each specimen were then carefully cut out and remounted on a black mat surface. The set of photographs of specimens was again retouched to obtain a balanced intensity of contrast. The completed mount was then rephotographed by a commercial firm (Bell) to produce the plate used in this thesis.


FORT ST. JOHN AREA
BRITISH COLUMBIA
SHOWING
COLLECTING LOCALITIES
LEGEND
SCALE: 1 INCH TO 8 MILES
A LOCALITY
4900-4944 MICROFAUNAL SUITE NUMBER
121°30'
121°00'
120°40'
120°10'
R.22
R.21
R.20
R.19
R.18
R.16
R.15
Tp. 85
Tp. 84
Tp. 83
Tp. 81
Tp. 80
Tp. 79
C 4500-4510
B 4600-4620
A 4900-4944
E 4200-4201
LOCALITY D
Charlie Lake
St. John Creek
Wilder Creek
Cache Creek
CHARLIE LAKE
Beatton River
Peace
FORT ST. JOHN
BALDONNEL
FORT ST. JOHN POST
Moberly River
River
Pine River
Septimus Creek
Kiskatinaw River
ALASKA HIGHWAY
BRITISH COLUMBIA
ALBERTA
Peace River
FORT ST. JOHN
DAWSON CREEK
N.A.R.
C.N.R.
EDMONTON
C.P.R.
CALGARY
INDEX MAP
SCALE OF MILES
100 0 100

APPENDIX - PART II

DESCRIPTION OF SECTIONS AND INDEX OF FORAMINIFERAL SUITES

The writer's foraminiferal suites were collected from the upper part of the Fort St. John formation, between the base of a fish-scale sand member to a point approximately 175 feet above the First Tuff, and 175 feet below the base of the Dunvegan formation (see p.14). The interval between the First Tuff and a point about 117 feet above the First Tuff is unsampled.

A. R. Nielsen (3a) completed a microfaunal study of the lower part of the Shaftesbury (Upper Fort St. John) formation in the eastern Peace River area, Alberta. Nielsen's microfaunal collections were taken from the upper part of the Peace River formation and the lower part of the Shaftesbury formation, using the base of a fish-scale siltstone band as a marker horizon in the latter formation.

The writer's microfaunal suites were taken from the following lithologic succession of strata:

LOCALITY A (Suites 4900-4944) Fort St. John formation from the base of the fish-scale zone to the Second Tuff, on Septimus Creek, British Columbia, in Sec.20, Tp.82, R.18, W6th. The section was described by W. G. Bahan, and the samples were collected by R. Sutherland and J. Ontko.

8" Tuff--rusty colored, irregularly-bedded; lowermost 2" contains spotty, poorly-consolidated, greyish-white tuff intermixed with yellowish tuff.
---This is referred to as the Second Tuff horizon in this report, and is figured in Plate II, Fig. 1, though not from the same locality.

1' 6" Shale--greyish-black, crumbly, with some pickeringite staining mostly in the bottom portion.
---Suite 4944 from base of above.

39' 10" Shale--grey, flaky, occasionally fissile with minor amounts of pickeringite staining giving it a greenish tinge; weathering a silvery-grey; contains occasional oblate ironstone nodules which probably contain ammonites.
---Suite 4943, 20' up from base of above.
---Suite 4942, 10' up from base of above.

3" Ironstone--grey, rusty-weathering.

14' 6" Shale--brownish-black; breaking off in irregular fragments not conforming with the bedding plane; minor pickeringite staining; weathers a brownish grey.
---Suite 4941, 10' up from base of above.

25' 6" Shale--brownish-grey, as above; lowermost 2' tending to be somewhat flaky; occasional fish scales; oblate ironstone nodules are found but not abundant and irregularly dispersed.
---Suite 4940, 20' up from base of above.
---Suite 4939, 10' up from base of above.

4" Ironstone--greyish-black, weathering rusty.

8' Shale--greyish-brown, breaking in irregular fragments; breaks do not conform with bedding planes; abundant fish scales and thin lenses of siltstone up to 1/8" thick irregularly dispersed throughout; occasional oblate nodules.
---Suite 4938, from top of above.
---Suite 4937, 3' up from base of above.

20' Shale--as above, with slight greenish tinge due to pickeringite staining; occasional oblate nodules.
---Suite 4936, 17' up from base of above.
---Suite 4935, 11' up from base of above.
---Suite 4934, 5' up from base of above.

11' Shale--greyish-black, flaky, somewhat fissile in irregular pattern and with faint pickeringite staining.
---Suite 4933, 10' up from base of above.
---Suite 4932, 5' up from base of above.

2" Ironstone--greyish, weathering rusty.

14' Shale--greyish-black, flaky, as above.
---Suite 4931, 12' up from base of above.
---Suite 4930, 6' up from base of above.
---Suite 4929, from base of above.

3" Ironstone--grey, weathering rusty.

1' 6" Tuff?--whitish-grey; partially consolidated; intermixed with yellowish bentonite.

25' Shale--brownish-black, irregularly fracturing, somewhat fissile, with abundant fish scales and occasional ¼" bands of yellow bentonite; abundant very fine needle-like crystals of gypsum present between bedding planes; occasional ironstone concretions up to 1' in diameter.
---Suite 4928, 21' up from base of above.
---Suite 4927, 15' up from base of above.
---Suite 4926, 9' up from base of above
---Suite 4925, 3' up from base of above.

10' Shale--as above.
---Suite 4924, 7' up from base of above.
---Suite 4923, 1' up from base of above

10' 6" Shale--greyish-black, as above, with faint pickeringite staining.
---Suite 4922, 5' up from base of above.

16' 3" Shale--flaky, somewhat fissile, brownish-black, with thin minute needle-like gypsum crystals between bedding planes; abundant fish scales in uppermost 5'; faint tinge of pickeringite.
---Suite 4921, 15' up from base of above.
---Suite 4920, 9' up from base of above.
---Suite 4919, 3' up from base of above.

2" Ironstone--greyish-black, weathering rusty.

15' Shale--greyish-black, flaky, with abundant fish scales; thin ¼" band of yellowish-grey bentonite 10' from top.
---Suite 4918, 12' up from base of above.
---Suite 4917, 6' up from base of above.

13' Shale--fissile, brownish-black, containing abundant fish scales.
---Suite 4916, 12' up from base of above.
---Suite 4915, 6' up from base of above.
---Suite 4914, from base of above.

33' Shale--brownish-grey, platy, heavily coated with pickeringite and containing abundant fish scales; weathering silvery-grey (typical fish scale shales); lowermost 3' tend to become very fissile.
---Suite 4913, 28' up from base of above.
---Suite 4912, 21' up from base of above.
---Suite 4911, 18' up from base of above.
---Suite 4910, 12' up from base of above.
---Suite 4909, 6' up from base of above.

	4"	Shale--brownish-grey, tuffaceous; contains numerous fish scales and gypsum crystals. ---Suite 4908, from top of below.
20'		Shale--brownish-black, irregular fracturing; contains fish scales but not as numerous as 33' section overlying it. ---Suite 4907, 18' up from base of above. ---Suite 4906, 12' up from base of above. ---Suite 4905, 6' up from base of above. ---Suite 4904, from base of above.
14'	3"	Shale--brownish-black, flaky; containing fish scales and minute needle-like gypsum crystals between bedding planes; also rare thin lenses of silt. ---Suite 4903, 8' up from base of above. ---Suite 4902, 2' up from base of above.
	8"	Siltstone--interbedded greyish-black and brownish-black, with rusty streaks and abundant gypsum between bedding planes; weathers rusty.
2'		Shale and sandstone--greyish-black, silty shale and fine-grained grey sandstone.
	6"	Siltstone--interbedded, greyish-black and brownish-black, with abundant gypsum between bedding planes; rusty-weathering. ---Suite 4901 from base of above. ---Base of fish scale zone. This is the base of the fish scale sand horizon marker as figured in Plate II, Fig. 2, though from a different locality. ---Top of <u>Neogastroplites</u> zone.
4'		Shale--greyish-black, flaky, with pickeringite staining between bedding planes; also with fine needle-like gypsum crystals between bedding planes; occasional lenses of siltstone. ---Suite 4900, from base of above.
2'		Shale and Sandstone--interbedded, greyish-black, silty shale, and greyish-black siltstone.

---Water level.

LOCALITY B (suites 4600-4620) Fort St. John formation from the First Tuff horizon to the Second Tuff horizon of Septimus Creek (locality A). The samples of this suite were collected between the same horizon markers, but at the mouth of St. John Creek on Beatton River, British Columbia, in Sec.14, Tp.84, R.18, W6th. The section was described by W. G. Bahan, and samples were collected by R. Sutherland.

1"	Bentonite--creamy-colored band.
6"	Shale--black, highly fissile, tending to become flaky, with brownish rust staining on exterior surface.
6"	Tuff--pink (characteristic color of First Tuff), highly consolidated; lowermost 2" contains abundant biotite flakes. ---This is known as the First Tuff in this report and is figured in Plate I, Fig. 2. ---Suite 4620, 3" up from base of above.
1' 6"	Shale--highly fissile, almost flaky. ---Suite 4619, from top of above. ---Suite 4618, from base of above.
½"	Bentonite--buff, somewhat tuffaceous.
1'	Shale--fissile, as above. ---Suite 4617, 6" up from base of above. ---Suite 4616, from base of above.
6"	Shale--very platy, flexible; containing small impregnations resembling buckshot holes. The individual lamellae are present in large pieces and have a tendency to overhang. This band and the one 4' below are figured in Figure 2, Plate I, though not from the same locality. ---Suite 4615, from base of above.
4'	Shale--black, fissile. ---Suite 4614, 2' up from base of above.
8"	Shale--flexible, as above. ---Suite 4613, from base of above.
1'	Shale--rusty, flaky, silty, with abundant gypsum crystals between the bedding planes.

2' Shale--greyish-black, crumbly, with occasional fish scales and abundant gypsum crystals between bedding planes; faint greenish tinge on exterior surface due to pickeringite staining.

$\frac{1}{4}$" Bentonite--a yellowish streak.

31' Shale--brownish-black, somewhat flaky, but fragments do not break regularly along bedding planes; contains minute gypsum crystals along bedding planes and abundant fish scales; slight tint of green due to pickeringite staining.
---Suite 4612, 25' up from base of above.
---Suite 4611, 18' up from base of above.
---Suite 4610, 12' up from base of above.
---Suite 4609, 6' up from base of above.
---Suite 4608, from base of above.

2" Ironstone--silty, stained with pickeringite on the exterior surface; slightly fractured, with abundant gypsum crystals and iron staining in the fractures.

1' Shale--greyish-black, flaky, with abundant gypsum crystals between bedding planes; fish scales present; considerable pickeringite staining.

3" Shale--badly weathered, tuffaceous; highly rusted between bedding planes and containing considerable gypsum crystals.
---Suite 4607 from base of above.

17' Shale--brownish-black, somewhat fissile, but parting not conforming with the bedding planes; somewhat conchoidal fracture; occasional fish scales.
---Suite 4606, 11' up from base of above.
---Suite 4605, 5' up from base of above.
---Suite 4604, from base of above.

1' 6" Pickeringite--yellow (pyritiferous shale?)

18' Shale--as above.
---Suite 4603, 12' up from base of above.
---Suite 4602, 6' up from base of above.
---Suite 4601, from base of above.

5" Tuff Bed--Second Tuff. This is the same horizon as the top of the Locality A section.

LOCALITY C (Suites 4500-4510) Fort St. John formation from above the cone-in-cone horizon to water level on Beatton River, British Columbia, in Sec.1, Tp.85, R.18, W6th. Descriptions were made by W. G. Bahan, and samples were collected by R. Sutherland and C. R. Stelck.

8'	Siltstone, Sandstone, Shale--alternating beds; siltstone up to 8" in thickness; siltstone bands weather a yellowish-brown; fresh surface grey; very minute biotite flakes present in the siltstone which is very finely bedded; the shale in this 8' section is greyish-black, silty, and contains black, carbonaceous materials, tending to rust on the outer surface.
4'	Shale--brownish-black, silty; breaks in irregular fragments not conforming with bedding planes.
2"	Shale--crumbly, intermixed with pickeringite.
6"	Tuff--speckled, whitish-grey, unconsolidated, highly bentonitic; contains considerable small fragments of biotite.
2"	Siltstone--greyish-black, poorly consolidated, shaly.
4"	Shale--greyish-black, crumbly, with considerable pickeringite present along fracture planes.
14'	Shale--greyish-black, silty, with a great deal of rusty staining on the exterior surface.
3"	Ironstone--greyish-black, silty, highly spotted with star-like markings which are composed of acicular material which tends to radiate out from a common centre.
6'	Shale--brownish-black, silty, as above.
3"	Ironstone--concretions with star-like markings and considerable marcasite nodules and small thin bands; this band is highly fractured.
11'	Shale--brownish-black, silty, as above.
2"	Ironstone--grey, silty, with occasional star-like markings and considerable marcasite streaks and bands toward the bottom.
2'	Shale--black, silty.
1"	Siltstone--grey.

1'		Shale--black, silty, tending to become somewhat fissile.
	2"	Siltstone--band of grey siltstone with very minute bands of marcasite irregularly dispersed throughout.
6'	5"	Shale--brownish-black, silty, tending to become fissile.
	5"	Cone-in-cone bed--band of silty material highly cemented and developed into a cone-in-cone structure; it has a greyish-yellow color on fresh surface and tends to weather a creamy-yellow; the uppermost 1" of this band is a grey siltstone. ---This is known as the Cone-in-cone horizon of this thesis and is contained in the section figured in Plate I, Fig. 1.
5'	6"	Shale--greyish-black, silty, fissile.
	2"	Ironstone--greyish-black, silty, with traces of marcasite.
5'		Shale--brownish-black, silty.
	1"	Ironstone--greyish-brown, weathering rusty.
9'		Shale--greyish-black, crumbly, highly rust-stained. ---Suite 4510, from base of above.
	3"	Ironstone--greyish-black, with few small lenses of marcasite dispersed throughout.
5'	6"	Shale--greyish-black, silty, crumbly; containing occasional small siltstone nodules which have a light brown rusty color, and a dark brown shaly exterior. ---Suite 4509, from base of above.
	2"	Ironstone--greyish-black, rusty weathering.
7'		Shale--greyish-black, fissile. ---Suite 4508, from base of above.
	2"	Ironstone--greyish-black.
5'		Shale--brownish-black, silty, tending to fracture into long slender fragments. ---Suite 4507, from base of above.
	2"	Ironstone--greyish-black, silty.
3'	6"	Shale--as above. ---Suite 4506, from base of above.
	4"	Cone-in-cone--band which consists of 2" of cone-in-cone and 2" of ironstone; cone-in-cone is developed out of a greyish-black, silty shale; the ironstone is very silty and has a grey color on fresh surface.

2'	6"	Shale--greyish-black, silty, containing several bands up to ½" of grey, very fine-grained sandstone.
	4"	Sandstone--the uppermost 2" consist of a bed of a bluish-grey color almost silty; the lowermost 2" consist of finely-bedded alternating greyish-black and grey, very fine-grained sandstone; weathers a whitish-grey.
	8"	Shale--brownish-black, silty, somewhat fissile.
	1"	Ironstone--greyish-black.
	8"	Shale--greyish-black, silty, as above.
	1"	Ironstone--greyish-black, weathering rusty.
6'		Shale--brownish-black, tending to become fissile. ---Suite 4505, from base of above.
	6"	Ironstone--greyish-black, silty; the uppermost 2" tend to form cone-in-cone structure and weathers a creamy color.
7'		Shale--greyish-black, fissile.
	2"	Ironstone--greyish-black; containing thin vein-like bands and nodules of marcasite.
2'		Shale--brownish-black, slightly silty, somewhat fissile.
	1"	Ironstone--greyish-black, with traces of marcasite.
5'		Shale--brownish-black, as above. ---Suite 4504, from base of above.
	2"	Ironstone--greyish-black, with thin veins of marcasite and a few small nodules.
5'	6"	Shale--brownish-black, as above. ---Suite 4503, from base of above.
	1"	Ironstone--brownish-black; faint traces of marcasite.
3'		Shale--brownish-black, as above.
	2"	Ironstone--brownish-black, with faint traces of marcasite.
4'		Shale--brownish-black, somewhat fissile, but tending to break in long slender pieces. ---Suite 4502, from base of above.
	3"	Ironstone--brownish-black, weathering rusty.

12'	Shale--brownish-black, fissile. ---Suite 4501, 6' up from base of above. ---Suite 4500, from base of above.
17'	---Covered to water level.
100'	---Estimated thickness of beds to the First Tuff horizon (found at the top of the section at locality B).

LOCALITY D Fort St. John formation on Wilder Creek, Sec.3, Tp.84, R20, W6th, British Columbia, from the base of the Dunvegan formation to the First Tuff horizon. Descriptions by W. G. Bahan and C. R. Stelck.

---Base of Dunvegan formation.
---Top of Fort St. John formation.

2'	Sandstone--bluish-grey, very fine-grained, bedded sandstone; weathers whitish-grey to light buff; the upper 1' of this sandstone is usually jointed.
2' 6"	Shale--silty, brownish-black; the uppermost 1' has a brown rusty coating and is cliff-forming like the overlying sandstone; the bottom 1' 6" weathers a greyish-black and forms a small bench.
1' 6"	Sandstone--very fine-grained, interbedded, whitish-grey and greyish-black sandstone; the intervals are very minute, giving a freshly broken surface a varved effect.
2' 10"	Siltstone--greyish-black, bedded siltstone, with minor thin lenses of brownish silty shale between the beds; the siltstone weathers a whitish-grey and forms a small bench to the underlying sandstone.
7'	Sandstone--light brownish-grey, weathering light buff, fine-grained, massive; the uppermost 2' appears to be bedded; jointing throughout.
1' 3"	Siltstone--the uppermost 0.3' is greyish-black, somewhat fissile, shaly siltstone; the remainder is brownish-black to greyish-black, somewhat sandy siltstone weathering to a whitish-grey; siltstone lenses.
2'	Sandstone--finely interbedded, cross-bedded, whitish-grey and buff, very fine-grained sandstone; weathering a buff grey; occasional lenses of greyish-black siltstone appear at irregular intervals throughout.

4'		Shale--brownish-grey, with purple staining, silty; this shale fractures in blocky irregular pieces; weathers a light brownish-grey.
1'		Sandstone--irregular shaped concretion composed of fine-grained, greyish-black sandstone; containing considerable fragments of black carbonaceous material.
21'		Shale--silty, with some siltstones.
1'	6"	Ironstone--concretions.
2'	6"	Shale--silty.
11'		Shale--very silty, with silty ironstone bands and occasional siltstone or micaceous sandstone lenses.
	6"	Cone-in-cone bed--This is the cone-in-cone marker horizon used in this report and is the same as that found near the top of the section at Locality C.
3'		Shale--as above.
47'		Shale--silty, with occasional nodules up to 10" x 5".
18'		Shale--no nodules.
	2"	Ironstone--almost continuous.
30'	6"	Shale--heavy-looking, sub-scarp-forming shale, with bands of ironstone.
	3"	Ironstone--silty to sandy.
7'	6"	Shale--silty.
	2"	Ironstone--silty.
1'	6"	Shale--very silty.
	1"	Ironstone--silty.
1'	6"	Shale--very silty, fissile.
9'	6"	Shale--with semi-continuous 1" ironstone bands.
3'		Shale--silty.
	¼"	Bentonite--white
11'		Shale--silty, fissile.

$\frac{1}{4}$"	Bentonite--white.
7'	Shale--silty, with sporadic 18" x 4" nodules.
$\frac{1}{4}$"	Bentonite.
32'	Shale--with ironstone.
18'	Shale--silty, with continuous ferruginous silt bands.
44'	Shale.
4' 6"	Shale.
6"	Tuff--First Tuff horizon marker. This is the same tuff horizon as found at the top of the section at Locality B.

LOCALITY E (suites from core #10-interval 520'-535') Dunvegan and Fort St. John formations. The Kiskatinaw test hole was drilled $\frac{1}{2}$ mile downstream from Kiskatinaw bridge on the Alaska Highway in NW$\frac{1}{4}$ Sec.26, Tp.80, R.17, W6th., British Columbia. The section from 0' - 90' was described from the Cutbank test hole at mile 30.3 on the Alaska Highway, in SE$\frac{1}{4}$ Sec.27, Tp.80, R.17, W6th., British Columbia. Sections were described by W. G. Bahan.

0'- 5'	Sandstone and Shale--fine to medium grained, grey, salt and pepper sandstone containing abundant biotite flakes; grey to light brown, silty shale containing abundant carbonaceous material; trace of coal.
5'- 10'	Sandstone and Shale--65% sandstone as above; 35% shale as above.
10'- 15'	Shale--grey, silty to sandy, containing abundant biotite flakes.
15'- 20'	Shale--greyish-black, silty, containing abundant mica flakes.
20'- 30'	Shale--as above; trace of fine to medium-grained, greyish-white salt and pepper sandstone.
30'- 40'	Sandstone--greyish-white, fine to medium-grained, salt and pepper sandstone, containing abundant biotite flakes.

40'- 50'	Sandstone--grey, shaly, highly glauconitic, containing abundant biotite flakes; greyish-white, fine to medium-grained sandstone containing abundant biotite flakes; trace of greyish-black, silty shale.
50'- 60'	Sandstone and Shale--grey to light buff, very fine-grained, shaly sandstone containing abundant biotite flakes; 30% greyish-black, silty shale.
60'- 70'	Shale--greyish-black to brownish-black, silty shale containing abundant biotite flakes 80%; greyish-white, fine to medium-grained, salt and pepper sandstone, containing abundant biotite flakes 20%.
70'- 80'	Sandstone--greyish-white, fine to medium-grained, salt and pepper sandstone containing abundant biotite flakes and occasional glauconite; trace of dirty grey, shaly, fine-grained sandstone; highly glauconitic. ---This is the base of the Dunvegan formation in this area.
80'- 95'	Shale--greyish-black to brownish-black, silty; containing abundant mica flakes.
95'-100'	Sandstone--grey, fine to medium-grained, with traces of glauconite. Great deal of river sand trailings.
100'-110'	Siltstone? - Sand-greyish-black.
110'-120'	Shales, silty? - Sand-as above.
120'-130'	Shales, silty? - Sand-as above; some chips of sandstone.
130'-140'	Shales, silty? - Sand-as above.
140'-150'	Shales and siltstones? - Sand-as above with some small chips of greyish-black sandstone.
150'-160'	Shales? - Chert- black, angular chert pebbles, with some angular quartz pebbles. (trailings)
160'-170'	Shales? - Chert- pebbles as above. (trailings from gravels)
170'-180'	Shale--black, few scarce pieces of black shale possessing a faint bituminous lustre. Gravel and Sand- as above.
180'-190'	Shale--black, with occasional pyrite chip.
190'-200'	Shale--black, containing thin thread-like veins of pyrite, some of the pieces are spotted with pyrite, 90%-10% brownish-black, very silty shale. Several chips of grey, somewhat salt and pepper sandstone containing fine flakes of biotite. Traces of brown glauconitic sandstone and pyrite.

200'-210' Shale--grey to greyish brown, silty shale containing abundant black carbonaceous material 90%-10% black shale as above; trace of pyrite; very fine to medium-grained grey salt and pepper sandstone.

210'-220' Shale--brownish-black, silty, containing black carbonaceous material; some pyrite.

220'-230' Shale--grey, containing abundant black carbonaceous material 50%; greyish-brown shale containing abundant black carbonaceous material. Pyrite.

230'-240' Shale--greyish-brown to brownish-black, silty shale containing abundant mica flakes, trace of black carbonaceous material. Trace of massive pyrite. Trace of black fissile shale.

240'-250' Shale--greyish-black to brownish-black, silty, with abundant mica flakes and traces of black carbonaceous material; trace of grey, somewhat salt and pepper sandstone containing mica flakes.

250'-260' Shale and Sandstone--greyish-black to brownish-black, silty, as above, 50%. Fine to medium-grained, greyish, salt and pepper sandstone containing abundant mica flakes, 50%. Trace of pyrite.

260'-270' Shale and Sandstone--greyish-black to brownish-black, silty shale as above, 70%. Grey, fine to medium-grained, salt and pepper sandstone, as above, slightly glauconitic. Trace of massive pyrite.

270'-280' Shale--greyish-black to brownish-black, silty, containing abundant mica flakes and traces of black carbonaceous material. Trace of fine-grained, grey, salt and pepper sandstone, slightly glauconitic and with abundant biotite flakes.

280'-290' Shale--greyish-black to brownish-black, silty, containing biotite flakes and black carbonaceous material.

290'-300' Shale--greyish-black, silty, containing abundant biotite flakes and occasional black specks of carbonaceous material. Occasional chips of grey, very fine-grained salt and pepper sandstone.

300'-310' Shale--as above; trace of pyrite.

310'-320' Shale--as above; trace of pyrite and ironstone.

320'-330' Shale and Sandstone--greyish-black, silty shale with considerable amount of black carbonaceous material, 70%; grey, somewhat salt and peppery, very fine-grained sandstone containing abundant biotite flakes and carbonaceous material, 30%. Trace of pyrite.

330'-340' Shale--greyish-black, silty, with abundant black carbonaceous material; trace of pyrite.

340'-350' Shale--as above; trace of light brown shales containing carbonaceous material.

350'-360' Shale--as above.

360'-370' Shale--greyish-black, silty, with carbonaceous material and mica flakes; somewhat fissile.

370'-375' Shale--as above; trace of very fine-grained, grey, salt and pepper sandstone containing abundant mica flakes.

375'-380' Shale--grey, sandy, almost a very fine-grained sandstone; trace of light brown creamy limestone.

380'-385' Shale--grey, sandy, containing abundant minute biotite flakes.

385'-390' Shale--as above.

390'-395' Shale--grey, sandy, as above.

395'-400' Shale--grey, sandy, as above.

400'-405' Shale--greyish-black to brownish-black, silty, containing abundant biotite flakes.

405'-410' Shale--greyish-black to brownish-black; trace of ironstone; trace of black carbonaceous shale.

410'-415' Shale--greyish-black, silty, containing some biotite flakes; trace of ironstone.

415'-420' Shale--as above; trace of pyrite.

420'-425' Shale--greyish-black, silty, containing biotite flakes, 90%; dark brown shale, 10%; trace of rusty brown tuff containing biotite flakes.

425'-435' Shale--greyish-black, silty, containing biotite flakes; trace of dark brown ironstone, trace of pyrite.

435'-440' Shale--greyish-black, silty, as above; trace of pyrite.

440'-445'	Shale--greyish-black, silty; trace of granular pyrite.
445'-450'	Shale--greyish-black, silty; trace of grey, very fine-grained sandstone.
450'-455'	Shale--as above.
455'-460'	Shale--greyish-black, silty, containing minute flakes of biotite.
460'-465'	Missing.
465'-470'	Shale--greyish-black to brownish-black, silty, containing abundant minute biotite flakes.
470'-475'	Shale--as above.
475'-480'	Shale--grey, silty, containing abundant minute mica flakes; trace of brown ironstone.
480'-485'	Shale--as above.
485'-490'	Shale--greyish-black, silty, as above.
490'-495'	Shale--as above.
495'-500'	Shale--greyish-black, silty, containing abundant biotite flakes; trace of brown ironstone; trace of grey tuff?, containing abundant biotite flakes.
500'-505'	Shale--as above; trace of massive pyrite.
505'-510'	Shale--as above; trace of dark brown ironstone.
510'-515'	Shale--grey, containing abundant biotite flakes; several chips of shale possess minute pits.
515'-520'	Shale--as above; trace of pyrite.
520'-525'	Shale--as above; trace of tuff(?); containing abundant biotite flakes; trace of ironstone.
525'-530'	Shale--greyish-black, silty, containing abundant biotite flakes; trace of pyrite. ---Suite 4201, from base of above.
530'-535'	Shale--as above. ---Suite 4200, from base of above.

KISKATINAW TEST -- Core description. Fort St. John formation below the Dunvegan formation. This core was obtained at locality E, and includes the interval from 370' to 535'. Core description by W. G. Bahan.

370'-385'		Core #1 Recovered 3"
		Sandstone--grey, very fine-grained, salt and pepper.
385'-395'		Core #2 Recovered 10'
		Shale--greyish-black, silty, thinly-bedded, in alternating light and dark beds giving it a varved appearance; abundant plant remains present in small lenses at irregular intervals throughout; occasional thin bands of dark brown ironstone present.
395'-410'		Core #3 Recovered 15'
		Shale--greyish-black to brownish-black, often becoming silty; occasional thin band of dark brown ironstone present; traces of carbonaceous material occasionally very abundant but spotty; at 400' shale contains minute pits.
410'-425'		Core #4 Recovered 13'
	5'	Shale--greyish-black, with traces of carbonaceous material.
	1'	Shale--greyish-black, silty, with traces of carbonaceous material.
	7'	Shale--greyish-black, poker chip; tends to flake off when freshly broken; traces of carbonaceous material.
425'-440'		Core #5 Recovered 10'
	8"	Shale--greyish-black, poker chip.
	2'	Shale--greyish-black, somewhat silty, with occasional traces of black and brown carbonaceous material.
	5'	Shale--greyish-black to brownish-black, occasional thin light brown bands of shale appear inter-bedded with the black shale.
	1' 6"	Shale--greyish-black.
	2"	Ironstone--brownish-black, with star-shaped whitish material which is slightly calcareous. This may possibly be one of the star-like marked concretions found in outcrops of the St. John.

440'-455'		Core #6 Recovered 5' 3"
5'		Shale--brownish-black, poker chip.
	3"	Ironstone--light brown, containing traces of carbonaceous material and star-like markings.
455'-470'		Core #7 Recovered 11'
11'		Shale--greyish-black to brownish-black, carbonaceous, containing silty interbeds at irregular intervals throughout; abundant biotite flakes present.
470'-480'		Core #8 Recovered 5' 3"
1'	2"	Shale--brownish-black, slightly carbonaceous.
	$\frac{1}{4}$"	Limestone--light brown.
3'	6"	Shale--greyish-black, fissile, highly carbonaceous.
	6"	Shale--grey, silty.
480'-490'		Core #9 Recovered 9'
4'		Shale--greyish-black, fissile, containing traces of pyrite.
5'		Shale--greyish-black to brownish-black, containing abundant pyrite in small blobs; thin streaks of light brown shale dispersed at irregular intervals throughout - not abundant.
520'-535'		Core #10 Recovered 5'
5'		Shale--greyish-black to brownish-black, with some thin bands of light brown ironstone; shale contains minute buck-shot-like pits, possibly flexible shale found below the First Tuff.
		---Suite 4201, 5' up from base of above.
		---Suite 4200, from base of above.

APPENDIX - PART III

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